MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA

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OF

THE GEOLOGICAL SURVEY OF INDIA

PREFACE.

FOR many years the third part of the *Manual of the Geology of India* (Economic Geology : by V. Ball) has been out of print and several projects have been formed for the production of a new edition. Under the first of these it was proposed to re-issue the publication in a series of separate volumes, each dealing with a single mineral, and a beginning was made with Corundum (by T. H. Holland) in 1898. It soon became clear, however, that this method of re-editing would extend over a very long period and the question of reproducing a revised manual on the original lines was reconsidered; articles were prepared by various members of the Geological Survey, but, pending the completion of the whole volume, were not published; it is hoped that the work will be issued before long in a short form with an extensive bibliography and in the meantime it has been decided to publish such articles as are likely to be of immediate interest. One of these is the article on coal, which was revised by Mr. R. R. Simpson, now Inspector of Mines, while he was still attached to the staff of the Geological Survey; this he has now further revised and brought up to date. I am indebted to Mr. G. F. Adams, Chief Inspector of Mines, for permitting Mr. Simpson to undertake the work.

H. H. HAYDEN,

Director, Geological Survey of India.

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MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

THE COALFIELDS OF INDIA. *By the late* PROFESSOR V. BALL, C.B., LL.D., F.R.S. *Entirely revised and largely re-written by* R. R. SIMPSON, M.SC., *Inspector of Mines,* formerly *Mining Specialist to the Geological Survey of India.*

Chief Works of Reference.

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CHAPTER I.

GEOLOGICAL OCCURRENCE OF COAL IN INDIA.

(i). The Gondwana Coalfields.

Stratigraphical arrangement.

The coal-seams of India occur in deposits younger than those in which the principal coalfields of Europe are found. With one or two unimportant exceptions the peninsular fields are confined to the great Gondwana (Permo-Triassic) system of Indian geologists. The rocks of this system are considered to have been almost entirely

deposited in fresh water and probably by rivers. As a rule they are found occupying basin-shaped depressions in the older formations, and such depressions frequently coincide with the existing river valleys. On the west these areas appear to be basins of original deposition, but on the east abrupt faulting on the southern margin of the fields points to the probability that these areas, in part at least, owe their preservation from denudation to the fact of their having been sunk by earth movements to a level lower than neighbouring portions of the same deposits. From the following table[1] the geological sequence of the coal-bearing portion of the Gondwana rocks can be understood :—

Lower Gondwana	Panchet .	Panchet	Almod ?	or Kamthi.
	Damuda	Raniganj .	or Bijori	
		Ironstone shales.	Motur.	
		Barakar.		
	Talchir .	Karharbari.		
		Talchir.		

The names of most of the groups are taken from the names of their representatives in the Bengal fields, which were first examined; the best sequence of the beds, however, is seen in the fields of the Narbada valley. The alternative names are those given by the early observers in the fields of the Narbada and Godavari valleys before correlation with the Bengal fields was attempted.

Talchirs.

Commencing with the lowest member of the system, the Talchir beds consist in general of fine, silty shales and fine, soft sandstones. The shales are usually greenish-grey or olive in colour, and are traversed by innumerable joints. The sandstones are fine, even-grained and vary in colour from olive to pale-pink. They are composed chiefly of quartz and *undecomposed* pink felspar. A thin coal-seam occurs amongst the Talchir beds in the Jhilmilli coalfield in Sarguja, but, as a rule, these beds do not contain coal-seams. Towards the base of the group the frequent occurrence of a remarkable boulder-bed containing striated pebbles points to the existence of glacial conditions in early Gondwana times. It may be remarked that the occurrence of a similar bed (Dwyka conglomerate) in an analogous position in

[1] *Manual of the Geology of India*, 2nd edition, p. 156.

the coalfields of South Africa is one of a number of facts pointing to the similarity in age of the coal-bearing rocks of both countries. The Talchirs attain their greatest development in the Raniganj coalfield, where their thickness is about 800 feet.

Karharbari beds.

The rocks of the Karharbari stage rest conformably on the Talchirs. They have been chiefly studied in the Giridih coalfield, where they attain a maximum thickness of about 800 feet, but their palæontological characteristics have been recognised in most of the peninsular coalfields. In 1879-81 Dr. Feistmantel, on palæontological grounds, classified the lower Karharbari beds with the underlying Talchirs, but Dr. Saise,[1] in the light of more recent exploration, considers the stratigraphical evidence strong enough to upset this classification and prefers to consider them as Barakars. They consist of white, grey, or brown felspathic sandstones, grits and conglomerates with coal-seams; a little shale is associated with the latter. The fragments of felspar and quartz of which the grits are composed are, as a rule, angular or sub-angular, and are thus sharply distinguished from those in the typical Barakars, which are usually well-rounded. The coal is dull-black in colour, and fairly uniform in structure. It bears a high character as a locomotive fuel.

The Damudas.

The Talchir-Karharbari group is succeeded by a great series of beds, the Damuda series, in which, with the doubtful exception of the Giridih field, occur the workable coal-seams of Peninsular India. It is divided into three stages which are known in Bengal as the Barakar stage, the Ironstone shales, and the Raniganj beds. Only the first and last of these are coal-bearing. The names Barakar, Motur and Bijori have been given to the same beds in the Narbada valley, but here the coal is confined to the lower division. In the Godavari region again, the Barakar is the only coal-bearing formation, and in this area the beds overlying the Barakars are known as the Kamthi stage. The total thickness of the Damuda series is 8,400 feet in the Raniganj field and about 10,000 feet in the Narbada basin.

The Barakar stage.

The Barakars attain their maximum development in the Jharia coalfield, where they are 3,300 feet in thickness. They are composed of sandstones, conglomerates, shales and coal. The sandstones are usually soft, coarse and

[1] *Rec., Geol. Surv. Ind.*, Vol. XXVII, p. 89 (1894).

felspathic and are made up of grains of quartz and *decomposed* or kaolinized felspar, the latter characteristic distinguishing them from sandstones of Talchir age. The typical Barakar sandstone is white, but other tints occur and in some parts predominate. The conglomerates are made up of small, well-rounded, quartz pebbles, usually embedded in a white sandstone matrix. The shales are grey, blue, or black, and are usually arenaceous and sometimes micaceous. The coals of the Barakar stage all agree in having a peculiar laminated appearance, due to their being composed of alternating layers of bright, and dull, shaly coal. Some of the seams exhibit a peculiar spheroidal structure, and round balls, up to more than a foot in diameter, break away from the mass when the coal is mined.

The Ironstone Shales.

Overlying the Barakar stage in the Raniganj, Jharia and a few other coalfields of the Damuda valley comes the Ironstone Shales stage. It attains a maximum thickness of about 1,500 feet, and is composed of black or grey shales with lenticular bands and nodules of clay ironstone, some of which is of the carbonaceous variety known as blackband.

The Raniganj stage.

In the Damuda valley the highest member of the Damuda series is the Raniganj stage, which attains a thickness of 3,000 feet in the Raniganj coalfield. It is chiefly composed of sandstones with some shales, and coal-seams. The sandstones are usually coarse and massive, white or brown in colour, showing decomposed felspar, and obliquely laminated. The shales are grey, red, brown, or black in colour and are occasionally ferruginous. The coal has the same peculiar, laminated appearance as that from the Barakars.

The Motur and Bijori stages.

In the Narbada valley the rocks of the Damuda series overlying the Barakars are known as the Motur and Bijori stages. They are chiefly made up of an immense thickness of sandstones, and do not contain workable coal-seams.

The Kamthi beds.

In the Godavari valley the equivalent beds have been called the Kamthi group. They are not less than 6,000 feet in thickness, and consist of quartz-pebble conglomerates, ferruginous grits, sandstones of varying characters,

shales and red or green clays. They are frequently unconformable to the Barakars.

The Panchet rocks.

Overlying the Damudas comes the Panchet series, which has a maximum thickness of 1,800 feet and is composed of coarse, white, or greenish-white, felspathic, and micaceous sandstones, the felspar of which is usually undecomposed. Bands of red clay are interspersed through the sandstones. The Panchet rocks are, as a rule, distinguished from the Damudas by the presence of red clay, the absence of coal or carbonaceous shales and the usually more micaceous character of the sandstones.

Character of Damuda coal.

In general the coal of peninsular India may be described as a laminated bituminous coal, in which dull and bright layers alternate. Much of it does not cake freely, while a not inconsiderable portion will not do so at all. However, from the coal of particular seams in the Raniganj, Karharbari and Jharia fields, fairly good qualities of coke can be made. In the Raniganj field the best coke has been made from the Sanctoria coal and in the Jharia field from Nos. 14, 15 and 17 seams. The percentage of ash in Bengal coal which is brought to market averages from 10 to 15, that is to say that coal with less than 10 per cent. of ash does not commonly occur, and coal with more than 15 per cent. does not, as a rule, find a ready sale. In the producing fields of Hyderabad, the Central Provinces, and Central India the ash content is much higher, particularly in the latter provinces, where the percentage varies from 15 to 25 per cent.

As regards the proportion of fixed carbon, which is the most important factor in the production of heat, the average in the Raniganj field is under 55 per cent., while in the Karharbari and Jharia fields it is probably about 10 per cent. higher. There is no case of a true anthracite having been discovered in any of these fields; but the crushed and powdered coal at the foot of the Darjiling Himalayas approximates in character to anthracite on account of the removal of its original volatile constituents.

The moisture or hygrometric water varies a good deal in the coals from the different fields. In those of the Godavari and Wardha areas it is exceptionally high, being often 14 per cent., while in the Raniganj field it varies[1] from 1 per cent. in the

[1] Saise, *Rec., Geol. Surv. Ind.*, Vol. XXXI, pt. 2, pp. 104-107 (1904).

Barakar or lowest stage to 3·81 in the lower seams and 6·86 per cent. in the upper seams of the Raniganj stage. A similar proportion appears to obtain in the corresponding stages of the Jharia field.

The quantity of sulphur and phosphorus is very variable in different seams, and though often large, coal is to be found sufficiently free from these impurities for the manufacture of iron and steel. The average of 31 assays of coals from Raniganj by Mr. Tween[1] gave sulphuric acid 0·07 per cent. and phosphoric acid 0·14 per cent.

Professor Wyndham Dunstan[2] gives the following analyses of Raniganj, Jharia and Giridih coals :—

Coalfield.	Phosphorus per cent.	Sulphur per cent.
Raniganj (average of 34 samples)	0·088	0·74
Jharia (average of 12 samples)	0·143	0·80
Giridih (average of 6 samples)	0·019	0·62

(ii). The Jurassic Coalfields.

Kutch.

Coal of Upper Jurassic age occurs in Kutch. Mr. A. B. Wynne in his memoir on the Geology of Kutch,[3] mentions several localities where coal has been worked to some small extent. The workings at Trombow were apparently the largest and here, a seam, measuring 16 inches, contained only 8 inches of good coal, the remainder being shale. The seams appear to be so thin and inconstant and the coal so brittle and intermixed with shale that they cannot be considered of any economic importance.

Trans-Indus Salt Range.

The occurrence of lignite in the Lower Jurassic rocks of the Trans-Indus Salt Range has frequently excited comment. The deposits are found amongst variegated sandstones and shales and are usually associated with pyritous shales. The seams are thin and

[1] *Rec., G. S. I.*, X, p. 156 (1877).
[2] *Rec., Geol. Surv. Ind.*, Vol. XXXIII, pp. 246-253 (1906).
[3] *Mem., Geol. Surv. Ind.*, Vol. IX, p. 86 (1872).

inconstant, but small workable areas occur near Kalabagh. Coal of the same age is said to occur in the Kohat district of the North-West Frontier Province, and in the Doab Valley, Afghanistan.

(iii). The Cretaceous Coalfields.

Khasia and Garo Hills.

Coalfields of Cretaceous age are found in the Khasia and Garo hills in Assam. The fields of the former hills usually occur as small basins of original deposition, lying on rocks of Purana age, and on Archæan gneiss. The rocks of these basins vary in thickness from about 600 to 2,000 feet, but thin out on the edges of the basins. They appear to be mainly composed of coarse sandstones, conglomeratic towards the base, and with occasionally an intermediate zone of fine, glauconitic sandstones. The coal-seams occur near the top of the series and the latter is in places capped by Lower Tertiary deposits.

(iv). The Tertiary Coalfields.

Coal of Tertiary age is found in the foothills throughout almost the whole of extra-peninsular India, from Baluchistan on the north-west to Assam on the north-east. It also occurs in Sind, Rajputana, Burma and in the Andamans and Nicobars. The majority of the seams are lignite. They occur in eocene rocks, and are almost invariably associated with characteristic beds of nummulitic limestone. In Upper Assam, however, important deposits of true coal are found, which are considered to be of middle Tertiary, probably miocene, age.

The characteristics of the coals of the extra-peninsular areas are so variable that they must be described under their separate headings below. Generally speaking, the Tertiary coals are bright, jetty and non-laminated, and they contain a larger proportion of volatile matter than the coal of the peninsular fields; many of them are extremely friable and susceptible to disintegration under exposure; they do not cake as a rule and the proportion of ash is usually small.

CHAPTER II.

DETAILED DESCRIPTIONS OF THE RESPECTIVE COALFIELDS.

(i). Introductory.

Extent of the coal-bearing rocks

In 1873, Mr. T. W. H. Hughes[1] put forward the following estimate of the extent of the known coal-bearing rocks in India :—

Name of area.	Square miles.
Godavari and its affluents . . .	11,000
Son	8,000
Sarguja or Gangpur	4,500
Assam	3,000
Narbada and its affluents . . .	3,500
Damuda	2,000
Rajmahal	300
Unsurveyed and uncomputed . .	2,700
	35,000

This estimate is probably somewhat in excess of the truth, but the additional evidence to date does not permit of a much closer approximation. Over a considerable portion of the area the coal-bearing rocks are covered by younger deposits and must lie at unworkable depths.

Number of Coal-fields.

Although the coal-mining industry has now been in operation in India for more than a century, and although there has been a steady increase in production and consumption, which has been especially notable in the last decade, still it must be stated that the development of the coal resources of the country is as yet in an imperfect condition. Of the numerous coalfields of proved value in India 18 are actually being worked, but only 7 are of any considerable importance, whilst 89 per cent. of the total output is produced in the Raniganj and Jharia fields. The reason for this state of things

[1] *Rec., Geol. Surv. Ind.*, Vol. VI, p. 65 (1873).

is not far to seek. Most of the coalfields are too remote from the ports and centres of manufacturing industry to render it possible for their produce to be carried to places where it would have to compete with fuel from the premier coalfields of Bengal, which fields, from their strategic position within easy reach of the coast, practically command the Middle Eastern market. That a lively spirit of enterprise is abroad is, however, evident from the fact that coal prospecting operations are in progress in nearly a dozen separate coalfields.

The following list gives the names of all the separate areas in which coal or lignite is known or reported to exist in India, Burma and adjoining territories. The names of those coalfields which are being worked to any extent at the present day are printed in capitals :—

Afghanistan.

Afghan Turkistan (Chahil and Shisha Alang Valleys, etc.).

Andaman and Nicobar Islands.

Assam.

Abor and Miri hills.

Daphla and Aka hills.

Naga, Patkai and Singpho hills.—Namchik R.; MAKUM; Jaipur; Nazira; Janji; Disai.

Mikir hills.—Longloi; Dissoma and Diyong rivers; Nambor and Doigrung rivers.

Garo hills.—Harigaon; Siju; Darranggiri; Rongrenggiri, Kalu river.

Khasia and Jaintia hills.—Maobehlyrkar; Cherrapunji and Maolong; Lairungao; Maosandram; Umblay R.; Umrileng; Wapung and Lenkensmit; Lakadong.

Sylhet and Cachar.

Baluchistan.

Thal-Chotiali; KHOST, SHARIGH, ETC.; SOR RANGE AND MACH.

Bengal.

Burdwan District (part of Raniganj coalfield); Darjeeling; Baxa Duars; Chittagong.

Bihar and Orissa.

Talchir; Rajmahal Hills; Jainti; Shahajori and Kundit Kuraiah; GIRIDIH; Raniganj (part of); JHARIA; Bokaro-Jharia; Bokaro Ramgarh; North and South Karanpura; Chopé; Ithkuri; Auranga; Hutar; DALTONGANJ.

Bombay.

Sind.—Lainyan. *Cutch.*—Trombow; Sisagadh; Guniri.

Kathiawar.—Than.

Burma.

Tennasserim.—Tendau-Kamapying; Little Tennasserim R.; Lenya R.

Henzada.

Thayetmyo.

Arakan.—Baronga Islands; Ramri Islands; Cheduba Islands, Sandoway.

Yenangyaung.

Pakokku and Myingyan Districts.—Panlaung R., etc.

Northern Shan States.—Lashio; Namma; Man-Sang and Man-Se-Le.

Upper Burma.

Shwebo District.—Kabwet.

Chindwin District.—Upper Chindwin R.

Katha District.—Pinlebu.

Bhamo District.

Central India.

UMARIA; Korar; Johilla; Sohagpur; Singrauli.

Central Provinces.

North-Eastern Area.—Ramkola-Tatapani; Jhilmilli; Bisrampur; Bansar; Lakhanpur; Panchbhaini; Sendurgar; Damhamunda; Rampur (Sarguja); Kuresia; Koreagarh.

Chhattisgarh.—Korba; Mand R.; RAMPUR.

Lameta Ghat, etc.

Wardha Valley.—WARORA; Ghugus; Wun; Sasti; Paoni and BALLARPUR.

Bandar.

Satpura Hills.—MOHPANI; Shapur (Betul); CHHINDWARA.

Hyderabad.

Kunnigiri; Madavaram or Damercherla; Lingalla; SINGARENI; Alapalli; Kamaram; Chinur; Tandur; Aksapur; Antargaon; Sasti.

Jammu and Kashmir.

Ladda-Sangar Marg; Siro valley; Lodhra, Mehowgala, Kalakot and Dandli; Ans river; Jehlam R.

Madras and Southern India.

Malabar and Travancore; Mysore; Pondicherry; Place's Garden, Chingleput; Bellary; Nellore; Kadapah; Kistna District.

Godavari valley.—Beddadanol; Damercherla (or Madavaram).

North-West Frontier Province.

Punjab.

Bhaganwala; DANDOT; Isa Khel; Choi, Attock; Dore valley, Hazara; Kalka.

Rajputana.

Bikanir.—PALANA.

United Provinces.

(ii). Afghanistan.

In 1841, Captain Drummond[1] in his enumeration of places in Afghanistan where coal has been found mentions the following localities:—Dobandi in the Ghilzai country; Hissaruk and Syghan in the Hazara country. The Dobandi seam is said to be thin and the Syghan coal ignites with difficulty. Captain Hutton[2] mentions a report that coal occurs in abundance in the hills of the Hazara country. Several of the specimens of supposed coal, which were forwarded to Mr. Prinsep by Sir Alexander Burnes for examination, proved indeed to be more or less combustible, but were not coal. They were products of petroleum, or clay or rock saturated with

[1] *Jour., As. Soc. Beng.*, Vol. X, 88 (1841).
[2] *Cal Jour. Nat. Hist.*, VI, 601 (1846).

them. In 1891 Griesbach[1] mentions the occurrence of thin seams of mesozoic coal, none of them more than half-an-inch thick, near Shinkai and Tangi in the Dobandi valley.

Similar beds were also found between Drang and the La Khugha (Atghoki on map) pass.

(iii). Afghan Turkistan.

(Chahil and Shisha Alang Valleys, etc.)

Coal seams believed to range in age from Permo-Carboniferous to Jurassie were found in Afghan-Turkistan by Mr. C. L. Griesbach.[2]

The supposed Permo-Carboniferous coal occurs as thin beds of anthracitic graphitic coal in altered micaceous shales to the north of the village of Ak Robat. Seams of graphitic coal are also stated to occur in the Koh-i-Daman. Mr. Griesbach concludes that " taking into consideration the report that coal-seams have been found near Ghazni, the inference may be drawn that the Ghazni coal, if such exists, belongs to the same formation as the graphite of the Koh-i-Daman and the anthracitic coal of the Ak Robat pass and Saighan.[3] In that case we may fully expect to meet with the older coal-measures, equivalent to our best Indian horizon (Karharbari-Talchirs) within easy reach of our Indian frontier.''

The Triassic[4] coal is well-exposed in the Chahil (Chil) valley. The beds consist chiefly of thick-bedded massive sandstones and grits and are much disturbed. Near the top of the section a few thin coal-seams are found. Lower down coal occurs at regular intervals of from 80 to 100 feet; several of these seams exceed 6 feet in thickness. Still further down a seam of apparently excellent coal, 10 feet thick, occurs. It is succeeded by carbonaceous shales and some distance below a seam of friable coal, 18 inches thick, is found. The thick coal-seam can be traced for a considerable distance up the slope of the Sabz Kotal. To the west in the Shisha Alang valley what is considered to be a continuation of the

[1] *Rec., Geol. Surv. Ind.*, XXV, 79, 87 (1892).

[2] *Rec., Geol. Surv. Ind.*, XIX, 241-9 (1886).

[3] Probably Drummond's *Syghan.* This material has been shown by more recent searches to be graphite rather than coal and of no value as a fuel; see *Mem., Geol. Surv. Ind.*, XXXIX, p. 57 (1911).

[4] Probably Jurassic rather than Triassic, see below p. 13

same coal-bearing rocks is exposed. Mr. Griesbach found 7 separate groups of coal-measures, each about 300 feet thick. In one of these groups to the north of Shisha Alang five coal-seams respectively, 5′4″, 6′6″, 6′0″, 12′0″ and 30′0″ thick were measured. The two thick seams contained a few partings of clay and in them the coal was rather friable.

Mr. Griesbach remarks: "If I assume the average thickness of the best coal-seam at 6 feet only, which could be worked over an area of 9 square miles in the immediate neighbourhood of Shisha Alang, I find that the available quantity of coal would be no less than 50 million tons. In this estimate I have left out of consideration the fact (1) that triassic coal-measures with large seams of coal are actually exposed over a large surface in the Chahil valley and the north-west slope of the Sabz Kotal, and (2) that permo-carbod strata with anthracitic seams appear between Saighan and Bamian and that, therefore, the conclusion is evident that the whole Lower Trias and Permian strata, *i.e.*, the equivalents of our Lower Gondwana series, must be buried below the upper cretaceous limestone of the intervening country. It is consequently almost certain that the entire northern Hazarajat is one vast coalfield, which is partially hidden by superimposed Cretaceous limestone."

In a recently published paper on the Geology of Afghanistan (*Mem., Geol. Surv. India*, Vol. XXXIX, pp. 31, 33), Mr. Hayden has given reasons for doubting the presence in this area of representatives of the fluviatile Lower Gondwanas, all the true coal-seams being probably of Jurassic age. There is no evidence therefore of the extension into Afghan Turkistan of the coal-bearing Damuda series, or indeed of any part of the Gondwana system, of India.

In the Jurassic rocks of the Doab valley, Mr. Griesbach records the occurrence of an irregular and impure coal-seam of about 2 inches thickness, near the upper boundary of the alum-shales.

In recent years certain of the coal outcrops in Afghanistan have been examined by Mr. Hayden, and Dr. W. Saise, but no published information is available.

(iv). Andaman and Nicobar Islands.

Traces of coal probably of youngest Cretaceous or oldest Tertiary age have been met with in several of the islands, but as yet no regular seam has been discovered. The deposits consist of nests,

which, in every case where excavation has been attempted, have been speedily exhausted.

In 1869 samples obtained from the sinking of a well on Viper Island were forwarded to the offices of the Geological Survey of India. The coal was a lustrous jet and from its appearance probably did not occur as a regular deposit. The result of the analysis of an average sample was as follows: [1]—

Volatile matter	26·0
Fixed carbon	50·8
Ash	23·2

In 1903 specimens of coal and fossil plants were forwarded to the offices of the Geological Survey of India by the Deputy Conservator of Forests, Andamans. The plants were dicotyledonous and probably of Tertiary age, whilst the coal showed Tertiary characteristics and appeared to be impure.

In 1845 Busch, and in 1846 and 1857-59, Drs. Rink[2] and Hochstetter[3] found coal on Little Nicobar, Trak, Tries, Milu, Kondul and Great Nicobar Islands. The former states that the nests of brown coal occurred without any order, sometimes in the sandstones and sometimes in the shale, and appeared to be derived from drift-wood. Mr. Ball subsequently confirmed the discoveries, but considered that so far as examination has yet gone there is no ground for believing that a valuable deposit of coal exists in the islands. This opinion is confirmed by Mr. G. H. Tipper[4] who recently explored portions of the interior of Great Nicobar and other islands of the group.

(v). Assam.

The Abor and Miri hills.—In 1846 coal was discovered by Lieutenant Dalton[5] on the Durjmu river at a point north of Dibrugarh. He reported that the seams are from 3 to 8 inches thick, and dip slightly towards the Brahmaputra. Fragments of coal were also found in the beds of the Subansiri and Sundri rivers.

[1] *Jour., As. Soc. Beng.*, Vol. XXXIX, pt. 3, p. 236 (1870).
[2] *Selections from the Records, Govt. India*, No. LXXVII, pp. 127-8 (1870).
[3] *Op. cit.*, p. 221.
[4] *Mem., G. S. I.*, XXXV, pt. 4 (1911).
[5] *Cal. Jour. Nat. Hist.*, VII, 213 (1846).

In the same year Captain Vetch[1] found a "very thin seam of remarkably fine, but singularly heavy coal" on the Dakaru stream, some 6 or 7 miles above the confluence with the Buri Suti and some considerable distance east of Dalton's find. He mentions a rumour of coal occurring on the Sisi river. Although without certainty, it is probable that these finds may be referred to the Upper Tertiary sandstones of Mallet,[2] La Touche[3] and J. M. Maclaren[4] in which the writers referred to record the frequent occurrence of lignite bands and semi-carbonized wood. J. M. Maclaren, however, in referring to specimens of "true coal" brought to him from the Subansiri river, mentions a circumstantial account of what might possibly be a burning coal-outcrop, such as has altered to coke much of the outcrop coal at Margherita in the Makum field.

Daphla and Aka hills.—Damuda rocks were discovered in 1875 by Colonel Godwin Austen[5] in the section in the Dikrang river. He records the finding of a much splintered and crushed coal seam which was from 5 to 6 feet thick and dipped 75° to E. S. E. In character the coal resembles that from the Darjiling foot-hills, and it is unlikely to be of future economic value.

In 1883-84 Mr. La Touche[6] encountered a continuation of the same belt of rocks in the Aka hills to the north of Tezpur. The rocks are well exposed in the valley of the Borholi river, where at least three coal seams were found, the thickest of which measured 18 inches. Their economic value was considered to be negligible.

The Naga, Patkai and Singpho hills.—The coal-bearing rocks of these ranges were described by Mallet[7] in 1874-5, whilst the information has been recently brought up to date by J. M. Maclaren,[8] R. R. Simpson,[9] H. H. Hayden,[10] and E. H. Pascoe.[11] They are best known in the Makum area, but they stretch for 40 miles

[1] *Cal. Jour. Nat. Hist.*, VII, p. 368 (1846).
[2] *Mem., G. S. I.*, XII, 297 (1876).
[3] *Rec., G. S. I.*, XVIII, 122 (1885).
[4] *Rec., G. S. I.*, XXXI, p. 191 (1904).
[5] *Journ. As. Soc. Beng.*, XLIV, p. 37 (1875).
[6] *Rec., G. S. I.*, XVIII, pp, 121-124 (1885).
[7] *Mem., G. S. I.*, XII, p. 269-363 (1876).
[8] *Rec., G. S. I.*, XXXI, pp.188-191 (1904).
[9] *Rec., G. S. I.*, XXXIV, pt. 4, pp. 199-239 (1906).
[10] *Rec., G. S. I.*, XL, pt. 4, pp. 283-319 (1910).
[11] *Rec., G. S. I.*, XLI, pt. 3, pp. 214-216 (1911).

north-east, and for a hundred miles south-west, being exposed only along the northern front of the Patkai range. They are considered to be of Tertiary, probably miocene age, and to exceed 2,000 feet in thickness. The most remote coal-bearing rocks that have been noted in these hills are on the flanks of Maiobum in the Dihing valley, where LaTouche [1] found two seams of hard, bright coal, the one of which is 3 feet in thickness and dips 20° to S. E., whilst the other has a thickness exceeding 6 feet. In the overlying sandstones of Upper Tertiary age lenticular bands of impure lignite, up to three feet in thickness, were found. This latter is the coal mentioned by Wilcox [2] in his account of the expedition to the Irrawadi in 1828. Another outlying patch of the coal measures was discovered by Maclaren in the Manabum Range, a long spur parallel with the Noa Dihing river. A limited examination did not reveal the presence of coal-seams. Passing south again to the principal range the same rocks occur in the Namrup, and in the Namchik. Between the Namchik and the Tirap there appears to be a gap, due no doubt to the embaying of the range and the consequent denudation of the coal measures to the plains' level. From the Tirap to the Namsang river, a distance of 20 miles, the measures appear to be continuous, and it is in this locality that they appear to have attained their maximum development and that the extensive mines of the Assam Railways and Trading Company are situated. In the Namsang the great reversed fault which runs along the base of the hills has either raised the seam sufficiently high to enable the Namsang stream to erode it completely or it lies hidden beneath the alluvium. A second reversed fault to the north-west has raised and exposed the coal measures along the north-western flank of the Tipam hills, from whence they strike east of Jaipur to a little beyond the Disang river. They are again brought to the surface by the same or similar faults in the hills south of Nazira and of Moriani.

Namchik river.—In 1911 Messrs. G. C. Webster and E. H. Pascoe [3] made a detailed examination of the coal in the Namchik valley. The seams were found in a small tributary on the right bank of the river. Sixty feet of coal were measured within a thickness of 360 feet of strata. The best seam measures 26 feet and contains

[1] *Rec., G. S. I.*, XIX, p. 112 (1884-1885).
[2] *As. Res.*, XVII, pp. 322, etc. (1828).
[3] *Rec., G. S. I.*, XLI, pt. 3, pp. 214-216 (1911).


OUTCROP OF
COAL SEAM
100 FEET THICK

three bands of clay aggregating 4 feet 3 inches in thickness. The dip varies from 42° to 65°. The quality of the coal is excellent. It is, however, doubtful if much of the coal lies above water level and could be worked without heavy pumping.

Makum.—The Makum field is the best known of the several coalfields lying along the lower ranges of the hills which form the southern boundary of the Lakhimpur and Sibsagar districts. The coal-bearing rocks dip at high angles towards the axis of the range, and their outcrops occur as a narrow strip some 18 miles in length by about one mile in breadth. The coalfield is probably faulted on the north, but such disturbance is hidden by the alluvial plain of the Dihing river, which flows parallel to, and about 3 miles from the northern boundary. The most valuable seams occur in the east of the field between the Tirap and Namdang streams, a distance of about 5 miles. Throughout this ground the existence of a coal-seam, from 15 to 80 feet in thickness and probably not averaging less than 50 feet, has been proved. Several other seams are also said to occur. The average dip of the rocks is about 40° and consequently the seams pass into depth at short distances from the outcrops. Fortunately from a mining point of view, the outcrops in many places are several hundred feet above the plains, and consequently facilities for working the coal by means of adit levels are afforded.

Mallet [1] in 1875 estimated that between the Tirap and Namdang streams within a vertical depth of 400 feet from the outcrop, there is a minimum quantity of 18 million tons of coal. Subsequent working has proved the great seam to have a greater average thickness than was apparent during the prospecting stage, and in 1900, Mr G. E. Harris,[2] the manager of the collieries, estimated that over the same ground above the natural drainage of the Ledo and Namdang streams, there is a total quantity of 90 million tons of coal.

Small quantities of coal had been mined from this field in early times, but extensive operations were not commenced until 1881, when a mining concession was obtained by the Assam Railways and Trading Company, who at once commenced the vigorous exploitation of the coalfield. A metre-gauge railway, 77 miles in length between the Brahmaputra near Dibrugarh and the coalfield,

[1] *Op. cit.*
[2] *Trans. Manchester Geol. Soc.*, XXVI, p. 578.

was speedily constructed and mines were opened at Tikak and in the Namdang and Ledo valleys. In 1884 the output of the colliery was 16,493 tons and since that time the production has steadily increased, the output during the last five years averaging 292,000 tons per year. In 1910 the output was 297,094 tons. Briquetting plant and machinery for washing the coal previous to coking has been in operation for some years past.

The coal is a brownish-black to black, hard, bright substance with an irregular cleavage. It does not soil the fingers when touched. It produces a hard, porous, somewhat dull-looking, but excellent coke, and is a valuable gas coal, yielding 10,900 cubic feet of gas per ton, the gas having an illuminating power of 17·2 sperm candles. The average composition [1] of 10 samples of the coal is :—

Carbon	75·90
Hydrogen	5·18
Oxygen and Nitrogen	12·42
Sulphur	2·32
Ash	2·03
Water	2·15

The average theoretical calorific value of the same samples was 7,447 calories, which compares very favourably with the value of 6,526 calories calculated for 31 Raniganj coals. The most serious defects of the fuel are the large amount of sulphur which it contains either as nodules or disseminations of pyrites, and the state of "small" in which it is placed on the market. In the first trials these defects were considered formidable but by the use of specially designed firebars and grates they have been overcome, and Assam coal has now a reputation as the finest coal in India, and the equal of many English fuels.

Jaipur.[2]—The coal-bearing strata of this field extend as a narrow fringe along the western edge of the Tipam hills. The field is divided naturally into three portions by the rivers Dihing and Disang, on the bank of the former of which and within a mile of the coal outcrops, is situated the town of Jaipur, which gives its name to the coalfield. The length of the outcrops known is about 24 miles. The dip of the rocks is to the east or towards the axis of the range, at angles of from 30° to 80°. Only the uppermost

[1] *Rec. G.S.I.*, Vol. XV, p. 61.
[2] Simpson, R. R.: *Rec., Geol. Sur. Ind.*, XXXIV, pp. 200-215 (1906).

R. R. Simpson, Photo. *G. S. I., Calcutta.*

LOWER INCLINE WITH SECOND AND THIRD INCLINES IN THE DISTANCE, TIKAK MINE, MAKUM.

part of the measures is visible at the surface, the remainder being sunk beneath the alluvium of the plains.

The thickest section of the rocks is to be seen in the Disang river where a thickness of 45 feet of workable coal in six seams has been measured. Mallet[1] estimated that between Tipam and Boruarchali (a distance of 15 miles) within 450 feet of the outcrops of the seams, and allowing that there is an average workable thickness of 15 feet, there is a total quantity of 20 million tons of coal. This may be looked upon as a minimum estimate for the outcrops of lower seams probably underlie the alluvium, whilst there is the probable extension of the field south-west from Boruarchali to be taken into account.

R. R. Simpson considered the outcrops near the Disang river to be the most promising and estimated that, over a mile of outcrop, 1½ million tons could be profitably extracted.

The quality of the coal is somewhat inferior to that from the Makum field, the average analysis of eight samples being as follows :—

Moisture	5·9
Volatile matter	34·7
Fixed carbon	55·0
Ash	4·4

Much of the coal is soft and crumbling at the outcrop, but seams of harder coal are found. As in the Makum coal, the sulphur content is somewhat high. A few quarries have been worked for local purposes on the outcrops of the seams but the total quantity of coal which has been mined is insignificant. A small mine was commenced at Hapjan in 1910 and a tramway 4 miles in length, conveys the coal to Namrup, Assam-Bengal Railway.

As the measures seldom or never rise to any considerable elevation practically the whole of the coal lies below the level of the alluvium and the sinking of deep pits will be necessitated when the field comes to be worked on a large scale.

Nazira.[2]—The Nazira coalfield lies some 20 miles south-west of the Jaipur field and 11 miles east of Nazira and is drained by the Saffrai, Tiru and Dikhu rivers. The coal-measures have a total length of about 16 miles and are highly inclined in a

[1] *Op. cit.*, p. 59.
[2] R. R. Simpson, *Rec.*, *G.S.I.*, XXXIV, pp. 215-241 (1906).

south-east direction. On the south the outcrops rise to an elevation of as much as 2,000 feet above the plains, but on the north they are partly concealed by alluvium, and it is highly probable that in this direction they are continuous below the alluvium with the Jaipur measures.

There is a large number of seams, but the majority of them are too thin to be workable. The thickest section occurs in the Saffrai river where there are said to be five workable seams, aggregating 73½ feet in thickness. Mallet[1] estimated that in the Saffrai area, over a length of 4½ miles, allowing an average thickness of 51 feet, there are, within 350 feet of the outcrops about 20 million tons of coal. The whole of this quantity lies below the alluvium. In the Tiru-Dikhu area the same writer has calculated that, allowing an average thickness of 18 feet of workable coal over a distance of 7 miles, there are, within 600 feet of the outcrop nearly 15 million tons of coal, much of which could be extracted by means of adit levels. These estimates make no allowance for the highly probable extension of the field to the north below the alluvium or for the southern unproved ground. R. R. Simpson calculated that in less than a mile of outcrop on the right bank of the Dikhu river nearly 2¼ million tons of coal could be obtained by means of adit levels.

The quality of the coal is similar to that from the Makum field and most of it is of the hard variety. The average analysis of 11 samples is :—

Moisture	5·5
Volatile matter	34·1
Fixed carbon	57·8
Ash	2·6

In former times a number of quarries and even pits were worked to supply fuel for the local tea gardens. No authentic records of the total amount of coal mined appears to be available. Recently prospecting operations on behalf of the Assam-Bengal Railway Company have been undertaken, and that company is contemplating the development of the coalfield.

Janji.[2]—This small and comparatively unimportant field lies about 8 miles south-west of the Nazira field and is traversed by the Janji river. The length of the narrow strip of coal measures

[1] *Op. cit.*
[2] Mallet: *op. cit.*, p. 75.

is less than three miles. The general dip of the strata is to south 30° east at a very high angle and the boundaries of the field are faults. There are not more than two or three known coal-seams and their thickness does not exceed 3 feet. An analysis of a two feet band in a seam of three feet thickness gave :—

Moisture	6·8
Volatile matter	33·8
Fixed carbon	52·9
Ash	6·5

Disai.[1]—This field is situated on the Disai river about 14 miles south-west of the Janji field. It has not been thoroughly explored and its boundaries along the strike of the measures are unknown. The proved length of the outcrops is about 5 miles. The prevailing dip is to south 30° east at varying angles, but there is a considerable amount of irregular disturbance. Five or six coal seams have been discovered ; two of which have thicknesses of three and four feet, respectively. The coal is soft and much crushed. An analysis of the four feet seam gave :—

Moisture	3·4
Volatile matter	36·9
Fixed carbon	54·9
Ash	4·8

The Mikir hills.—The Mikir hills occupy a tract of country lying to the south of the Brahmaputra, between Nowgong and Golaghat. The Jamuna river, with its tributary the Deolao cuts through the hills from east to west, some 20 miles north of Lumding, dividing them into the north and south Mikir hills, the former also being known as the Rengma hills.

In 1896-97, Mr. F. H. Smith [2] found exposures of coal in the following localities within the area. Longloi hill, Meyongdisa valley (Dilangsao and Langator streams), Diphu river and Nambor river. In only the first and last mentioned places did he consider the deposits to be of any economic importance.

Longloi.—On the thickly jungle-clad slopes of Longloi hill a single exposure is seen of a coal-seam of doubtful Cretaceous age, 12 feet thick dipping from 10° to 20° to north-north-west. The

[1] Mallet : *op. cit.*, p. 76.
[2] *Mem., G.S.I.*, XXVIII, p. 93 (1900).

coal is brownish-black in colour and contains many specks of fossil resin. Analyses of two specimens gave the following results :—

	Top of seam.	Base of seam.
Moisture	5·36	3·88
Volatile matter	49·96	57·52
Fixed carbon	25·32	25·40
Ash	19·36	13·20

As the coal is of extremely poor quality, and is distant 12 miles—as the crow flies—over difficult country from Lumding on the Assam-Bengal Railway, it does not appear that the deposit at the present time is of much economic importance.

Dissoma and Diyang rivers.—Coal in these localities was reported on by Dr. Saise in 1904. On the Dissoma there are two seams of lignite, respectively 3 feet $10\frac{1}{2}$ inches and 3 feet $3\frac{1}{2}$ inches in thickness. The mean of two analyses of the coal gave :—

Moisture	13·00
Volatile matter	34·90
Fixed carbon	46·30
Ash	5·80

The seams dip steeply at angles of 37° and 25° respectively. Dr. Saise did not consider them workable at a profit considering the nearness of the locality to the vast supplies of superior fuel in the Naga and Patkoi hills.

On the Diyang occur two discontinuous seams of lignite of poor quality varying from 6 to 18 inches in thickness and dipping at 45° and 80° respectively. They were pronounced worthless.

Nambor and Doigrung rivers.—About 8 miles above the falls on the Nambor river a small patch of coal-bearing rocks (Cretaceous or Tertiary) occurs. Coal is exposed in the river bed in three places, but owing to the broken section Mr. Smith considered that they may be outcrops of the same bed. The minimum thickness in the best-exposed section is 7 feet and the seam dips at an angle of 8°. The average analysis of three samples is :—

Moisture	10·05
Volatile matter	31·58
Fixed carbon	26·94
Ash	31·43

The samples were taken from under water and therefore the quality of the coal may be better than the analysis indicated.

LaTouche[1] has recorded the occurrence of coal beds which may perhaps be continuous with the Nambor deposit, at a point on the Doigrung river about three or four miles to the west. A single seam of coal 3 feet thick and dipping west-north-west at a low angle is exposed twice in the bed of the stream. Owing to the inclusion of specks of resin in the coal he presumed that the beds are of Cretaceous age. A single analysis yielded nearly 49 per cent. of ash, an even worse result than that from the Nambor coal.

Both these localities were visited by Mr. H. H. Hayden[2] in 1902. His report confirms the unfavourable opinion expressed above.

Garo Hills.—The first published account of coal discoveries in the Garo hills appears to be that of Mr. James Bedford, who in 1842 explored the so-called Kurribari coalfield and mentions the occurrence of coal outcrops at Salkura, Champagiri and Mirampura.

In 1868 and 1874 H. B. Medlicott[3] examined the whole of the known outcrops. He reported that the main mass of the Garo hills is composed of gneiss to the south of which against the flank of the Tura range, Cretaceous rocks covered by Tertiary deposits are banked up. These Cretaceous rocks are probably continuous for fully 50 miles and in them coal is found in two localities; one on the Sumesari river, north of Shushung-Durgapur in Mymensingh, the other in the neighbourhood of Harigaon at the west base of of the hills near the Brahmaputra. Neither of these outcrops shows good coal, but, from the fact that the outcrops are all at the very margin of the original area of deposition, he considered that there was promise of improvement to the dip beneath the covering Tertiary deposits and suggested a trial boring at Dipkai, about 2 miles north-east of Putimari Haut. To the north of the main basin outliers of Cretaceous rocks have escaped denudation at Daranggiri, Rongrenggiri and Kalu and in the first named locality coal of excellent quality has been found.

Harigaon.—This is the locality of Mr. Bolton's "Kurribari coalfield." The coal at Salkura and Mirampara is, however, merely a resinous shale, whilst at Champagiri, more to the north and between the other two places, it is a thick bed of dark, stiff clay, with

[1] *Rec., G.S.I.*, XVIII, p. 31 (1885).
[2] *Mss. G.S.I.* (1902).
[3] *Rec., G.S.I.*, I, 11 (1868); VII, 58 (1874).

insignificant strings of lignite through it. In a stream near Tura, 8 miles to east-30°-south of Harigaon hill the deposit consists of few sticks of lignite scattered through sandstone.

Siju.—In the Ryuk valley a crushed coal-seam 3 feet thick, and dipping at 80° is found. It is very unequally carbonaceous being locally split by strings of clay and of sand, and it contains but few thin strings of tough, highly resinous coaly substance which burns readily leaving a skeleton of ash. In the Siju valley the same band occurs and here the quality of the coal is a little better. Neither of the exposures, however, contains coal of sufficiently good quality to bear transport to a distance. In former times an attempt to work the Siju coal was made by the Rajah of Sushung.

Daranggiri.—This coalfield is situated on both sides of the Sumesari river, about 6 miles north of Siju. The coal-bearing rocks are of Cretaceous age and lie in a basin on the gneissic floor of the hills. They have a total extent of about 50 square miles, but only the western half lying between Daranggiri and Rengchi, an area of about 20 square miles contains coal of workable quality.

There are six coal seams, but only one is of workable dimensions. The latter varies from $3\frac{1}{2}$ to $7\frac{1}{2}$ feet in thickness and it has been calculated by Mr. LaTouche,[1] who reported on the field in 1882, that it contains 76 million tons of coal.

The coal is bright-black in colour, becoming brown when crushed and contains numerous specks of resin. The assay of two samples gave the following average composition :—

Moisture	8·8
Volatile matter	36·3
Fixed carbon	49·8
Ash	5·1

Except on the south-west where the rocks are bent up sharply against the gneiss, the rocks dip at very low angles ; and owing to the position of the coal above the main drainage channels most of it could be extracted and the mines drained by means of adits.

In 1910 the attention of capitalists was drawn to the field and prospecting work was carried on. The considerable distance from a railway is the only bar to exploitation.

Rongrenggiri.—Some miles to the west up the valley of the Sumesari another basin of Cretaceous rocks is found. In 1882 LaTouche [2]

[1] *Rec., G.S.I,* XV, p. 175 (1882).
[2] *Ibid.*

reported that with the exception of a single seam of good coal, 1 foot thick, east of Shemshanggiri, no coal outcrops had been discovered; although a bed of carbonaceous shale about three feet thick occurs and probably represents the principal seam of the Daranggiri field.

At a later date P. N. Datta[1] added three outcrops to that mentioned by LaTouche, the thickest being 18 inches. Dr. King[2] in reviewing the known information regarded it as questionable whether the field could be worked even were the locality less difficult of approach than it is.

Kalu river.—On the upper Kalu, near Chipagiri, there is a small shallow basin of Cretaceous rocks, but no trace of coal has been observed.

Khasia and Jaintia hills.—Coal of both Cretaceous and Tertiary age has been long known to exist in these hills. The occurrences in a few localities were reported on in considerable detail by Dr. Oldham in the first volume[3] of the *Memoirs of the Geological Survey of India.* Ball[4] mentions the following localities with their elevations where coal is known to exist:—

Khasia hills :—

(1) Byrang, altitude 1,242 feet above sea-level;
(2) Cherrapunji, 4,118 feet;
(3) Lait-ryng-iew (Lairangao ?), 4,800 feet;
(4) Maolong, 600 feet;
(5) Maastoh, 1,500 feet;
(6) Mao-syn-ram (Mousandram ?), 4,000 feet;
(7) Maodon (Modong ?), 400 feet;
(8) Mao-nai-chora, 300 feet;
(9) Mao-beh-lyrkar, 5,000 feet;
(10) Shella (Chela ?), 800 feet;
(11) Thanjinath, 4,400 feet;

Jaintia Hills :—

(1) Amwi, 3,800 feet;
(2) Lakadong, 2,200 feet;
(3) Narpu, 500 feet;

[1] *Annual Report, G.S.I.*, 1891; *Rec., G.S.I.*, XXV, 6 (1892).
[2] *Ibid.*
[3] *p.* 185.
[4] *Manual, Geol. Ind.*, part III, p. 108.

(4) Sah-tyng-gah (Satunga ?), 3,500 feet;
(5) Sher-mang, 4,000 feet.

The additional localities discovered since this list was drawn up are:—

Khasia Hills.—Langrin, Nongbredem, Um-rileng;

Jaintia Hills.—Borsora, Wapung and Lenkensmit, Jarain, whilst many of these fields have been examined and described by various officers of the Geological Survey.

Mao-beh-larkar.—This tiny field of Cretaceous coal has an area of about 11 acres only. It is situated near the Bogopani river, about 19 miles south of Shillong; the workable coal seam has an average thickness of about 3 feet. The coal is compact, splintery, has a smooth conchoidal fracture and a woody sound when struck. It contains numerous specks and small nests of fossil resin, and a considerable quantity of sulphur as iron pyrites. LaTouche [1] has stated that at a moderate estimate the field contains some 52,000 tons of coal. For many years the coal of this field was worked for supplying the station of Shillong.

Mallet [2] has described the occurrence of coal near Moflong, about 5 miles north of Maobehlarkar. In two localities, near Umsaomat, the seams are only one foot thick and are shaly. On Dedum hill, however, a seam, three feet thick, occurs and appears to be workable.

The following analysis of the Maobehlarkar and Dedum coals have been published [3]:—

	Maobehlarkar.	Dedum hill.
Moisture	3·4	6·0
Volatile matter	39·6	24·6
Fixed carbon	55·2	37·8
Ash	1·8	31·6

Cherrapunji and Maolong.—In this neighbourhood coal of Tertiary age occurs in several localities, usually on a horizon some 10 to 15 feet above the nummulitic limestone. The thickness of the seam is extremely variable but near Cherrapunji an area of about $\frac{1}{4}$ square mile has been considered to be workable. In this area the coal is from 3 to 7 feet in thickness and lies almost horizontally.

[1] *Rec., G.S.I.*, XXIII, p. 123 (1890).
[2] *Ibid*, Vol. VIII, p. 86 (1875).
[3] *Ibid., loc. cit.*

From the following analysis by Mr. James Prinsep the quality of the coal appears to be excellent:—

	Per cent.
Volatile matter	37·1
Carbon	62·0
Ash	0·9

Captain James found that the coal yielded 10,200 cubic feet of gas of 15 candle power per ton, leaving 58 per cent. of coke. He states that the coal is hard, has an irregular fracture and would make an excellent steam coal.

LaTouche,[1] who examined the field in 1889, estimates that it contains nearly 1,200,000 tons of coal. He points out a clerical error in Dr. Oldham's previous estimate [2] of from 387,000 to 447,000 tons, which accounts for the discrepancy between the two estimates.

In former times the coal was worked on a small scale, but owing to the cost of transport to markets the mining operations were not commercially successful. During 1904 prospecting was taken up by the Maolong Lime and Coal Company, Limited, but so far they are said [3] to have met with indifferent success, the coal seam being very irregular at the point of trial.

Lairangao.—This field lies about 7 miles north of Cherrapunji, and is of the same age as the Cherra coalfield; the two having been separated from one another by denuding agencies. The dip of the measures is to the south at a slight angle, and the average thickness of the seam is about 3 feet. According to LaTouche[4] this thickness prevails over an area of about half a square mile, and the total quantity available is about one million tons. The same author does not consider the coal to be of such good quality as the Cherra coal, but pronounces it to be a useful fuel which might be taken into Shillong at a cheaper rate than the Maobehlarkar coal.

Maosandram.—This little field lies on the ridge between the Bogopani and Um Gni streams, and is about 1½ miles north of Maosandram and 12 miles west of Chela.

[1] *Rec., G.S.I.*, XXII, p. 169 (1889).
[2] *Mem., G.S.I.*, I, p. 192 (1858).
[3] *Colliery Guardian, Ind. and Col. Suppl.*, I, 20 (1904).
[4] *Rec., G.S.I.*, XXIII, p. 120 (1890).

The coal measures, which are of the same age as the Cherra and Lairangao deposits have an area of about 22 acres and are found outcropping round the summits of three small knolls.

The coal seam is occasionally as much as seven feet in thickness, but the average thickness of good coal is not more than two feet; at which thickness LaTouche[1] estimates that the total quantity of coal is about 63,000 tons. The quality of the coal is poor, but the seam has been mined to some small extent for lime-burning purposes.

Umblay river.—This coalfield is situated in the south-western Khasia hills. It was first visited by Colonel Godwin-Austen[2] who reported that the measures are of Cretaceous age and are persistent over a large area. He mentions four seams with a total thickness of 20 feet 4 inches of coal.

In 1883-84, it was visited and reported upon by LaTouche,[3] from whose description the following details are taken:—"The coal-bearing rocks are exposed over an area of about 30 square miles. They are situated at an average height of 1,500 feet above the plains in a roughly triangular plateau, bounded on the north by a steep scarp overlooking the river Um Blay. The rocks dip to the south-west at about the same inclination (5°-7°) as the surface of the plateau, but plunge steeply beneath the alluvium of the plains at an angle of 30°. On the Um Plu three workable seams occur with a total thickness of 15 feet of coal. In the ravine which debouches on the plains near Borsora three seams are also exposed, the total thickness of coal being 13 feet 2 inches. Coal is also seen near the villages of Nongyon, Nongkerasi, Nongmaotien and Lakima."

Although Mr. La Touche makes no estimate of the total amount, it is evident that a very large quantity of coal is available in this locality. From the following analysis of samples from near Borsora it appears that the coal is of very fair quality:—

	No. 1 seam, 3′10″.	No. 2 seam, 3′4″.
Moisture	5·84	3·02
Volatile matter	35·16	39·58
Fixed carbon	50·40	50·80
Ash	8·60	6·60

1 *Rec., G.S.I.*, Vol. XXIII, p. 122 (1890).
2 *Jour., As. Soc. Beng.*, Vol. XXXVIII, pt. 2, p. 1 (1869).
3 *Rec., G.S.I.*, Vol. XVI, p. 164 (1883) XVII, p. 143 (1384).

The coal varies from black to brown in colour, has a bright fracture and includes specks of fossil resin. Some of it has a caking quality.

Um Rileng.—One of the most recent discoveries of coal in these hills is that made by P. N. Bose [1] at the foot of Dinghu hill, close to the headwaters of the Um Rileng river and about 7 miles north-west of Shillong. The ground is much covered up by dense grass jungle, and few exposures are found. Pits and trenches have however, proved the existence of a thickness of from 9 to 10 feet of coal in two seams, over an area of nearly 100 acres; and Mr. Bose calculates that in this area, allowing for an average thickness of 5 feet, there are considerably more than half a million tons of coal.

The average analysis of two samples show the coal to have the following composition:—

Moisture	16·69
Volatile matter	45·51
Fixed carbon	31·57
Ash	6·23

In appearance the coal is woody and it contains nests and strings of fossil resin. There is also some iron pyrites. From the large amount of moisture in the fuel it does not appear likely that the coal will ever come into use for more than local purposes.

Wapung and Lenkensmit.—Occurrences of Cretaceous coal were found by P. N. Bose [2] at Wapung (seven miles east of Jowai), and at Lenkensmit (Dongchala on map), six miles south of Wapung. The seams are very variable and nowhere exceed 5 feet in thickness. The coal is of excellent caking quality.

From the exposures observed at both places, there is a probability of a workable extent of the coal; but, under the present circumstances, the cost of transport to the plains of Sylhet or Cachar is considered to be prohibitive.

This is probably the same coal as that noticed by LaTouche [3] at Jarain, where thicknesses of three to three and a half feet of coal were measured. Owing to the pyritic inclusions within the coal he considered it to be of little value.

[1] *Rec., G.S.I.*, Vol. XXXI, p. 35 (1904).
[2] *General Report, Geol. Surv. Ind.*, 1901-02, p. 18.
[3] *Rec., G.S.I.*, Vol. XVI, p. 199 (1883).

Lakadong.—The coalfield of Lakadong is situated near the southern edge of the Jaintia hills, about 7 miles from the plains at Burghat on the Harri river and at an elevation of about 2,200 feet above them.

The coal seam is of Tertiary (eocene) age, and is found outcropping round the edges and near the top of several small plateaus. As in the case of the Cherrapunji deposits, the coal seam and its accompanying beds were evidently at one time continuous over a large area, the intervening portions having been subsequently removed by denudation. The thickness of the seam varies from nothing up to 10 feet but the average thickness is not more than 2 feet.

The two most important coal-bearing areas are the Umlotodo and Umat plateaus, which on the line of the outcrop of the seam have a combined area of rather more than half a square mile.

In 1852 Dr. Oldham,[1] after an examination of the coalfield, estimated the total quantity of coal in the Umlotodo plateau to be $1\frac{1}{2}$ million tons. In a more recent and detailed report LaTouche[2] calculates that the total amount of coal in the two plateaus is 1,164,000 tons. As described by the latter the coal is bright and of good quality, but is traversed by numerous small joints which cause it to split into small cuboidal fragments.

Owing to its position near the top of the plateaus the depth of the coal below the surface is not more than from 10 to 20 feet and thus its extraction by small pits and adits is rendered simple. Workings have been carried on intermittently for more than 50 years, but the total amount of coal extracted appears to be small. In 1889 the exploitation of the field was contemplated by certain Calcutta firms, but they appear to have taken no practical steps to that end. Some distance to the north of Lakadong, the occurrence of coal has been recorded by LaTouche.[3] The localities are near the villages of Nokhara and Satunga; and the seams are said to be one foot and one foot nine inches, respectively, in thickness.

Sylhet and Cachar.—So far as is known there is no workable coal in either Sylhet or Cachar, the Lower Tertiary and Cretaceous rocks being covered up by newer deposits. In the North Cachar hills a

[1] *Mem., G.S.I.*, Vol. I, pt. 2, p. 145 (1858).
[2] *Rec., G.S.I.*, Vol. XXIII, pt. 1, p. 14 (1890).
[3] *Rec., G.S.I.*, Vol. XVI, pt. 4, pp. 200-201 (1883).

few thin bands of coal were found by F. H. Smith[1] in a railway tunnel to the south of Kayeng, but they are only a few inches each in thickness, and of no economic importance.

From time to time samples have been sent to the Geological Survey offices, but they have invariably proved to be lignites and jetty coals from the nests which so commonly occur in the younger Tertiaries.

(vi). Baluchistan.

Thal Chotiali, etc.—Coal of good quality was discovered in the Chamarlang valley in the Luni Pathan country, about 75 miles west of Dera Ghazi Khan, by Sir R. Sandeman. In 1874 Ball [2] visited the locality and found that the principal coal-seam is only 9 inches thick, and that there are numerous thinner bands. He pronounced the measures to be of Lower Tertiary age, and gave reasons for doubting that a workable coal-seam would be found.

Coal of the same age was discovered by officers [3] of the Geological Survey in 1891 during the course of the detailed mapping of Thal Chotiali and the Mari country. Near Duki, about 40 miles west of Chamarlang, several seams occur but the thickest is not more than 14 inches. In the Mari country near Khatan, well-known for its petroleum springs, a thin band of impure coal was found.

Khost, Sharigh, etc.—In the hills flanking the frontier section of the Sind-Pishin Railway at a height of about 4,000 feet above sea-level coal of Tertiary (eocene) age is found over a considerable area of country. The rocks, as a rule, dip at high angles towards the axis of the range and are much disturbed by faults and landslips.

In 1880 Griesbach[4] and in 1881 Blanford[5] visited the locality and reported unfavourably of the then known outcrops of coal. The latter describes a section near Sharigh in which not less than thirty coal-seams are to be found within a vertical thickness of 370 feet of strata. He states, however, that most of them

[1] *Mem., G.S.I.*, Vol. XXVIII, Art. 4, p. 72 (1898).
[2] *Rec., Geol. Surv. Ind.*, Vol. VII, p. 145 (1874).
[3] *Rec., Geol. Surv. Ind.*, Vol. XXV, 23, 29 (1892).
[4] *Mem., Geol. Surv. Ind.*, Vol. XVIII, 27 (1881).
[5] *Rec., Geol. Surv. Ind.*, Vol. XV, 149 (1882).

are less than six inches, and many only from 1 to 2 inches in thickness, whilst but four are as much as or exceed one foot, and of these two are chiefly composed of shale. The thickest seam was said to be 21 inches in thickness, to be non-coking and to have the following analysis :—

Moisture	6·8
Volatile matter	40·8
Fixed carbon	47·6
Ash	4·8

In 1889, E. J. Jones made an exhaustive examination of the deposits between Kach and Sunri, the results of which were reported by Dr. King[1] after a personal examination of the principal localities. The latter mentions the occurrence of coal outcrops at Mud Gorge Railway station, 3 miles west of Dirgi railway station, Khila Hakim Khan, Khost, Khila Ali Khan, Sharigh, Harnai and Nasak. He estimated that in the 26 inches seam at Khost, within 1,000 feet of the outcrop, there were more than 800,000 tons of coal. The mean of six analysis of Khost coal, cited by Dr. King is :—

Moisture	2·29
Volatile matter	41·51
Fixed carbon	46·52
Ash	9·68

The coal cakes well but contains a large amount of sulphur as iron pyrites.

In 1890 R. D. Oldham[2] examined the Sharigh-Spintangi section mentioning outcrops at Sunari Railway station, Harnai, and Sharigh. In the last-mentioned locality he records the occurrence of ten or more seams exceeding 4 inches in thickness. His report, however, was unfavourable, despite the fact that he found two seams of good coking coal respectively 15 and 17 inches thick at a point 2 miles south-west of Harnai.

Griesbach[3] revisited the coalfield in 1893 and reported on the Chappar Rift—Harnai section. He emphasized the extreme disturbance of the beds caused by the long-continued dissolving out

[1] *Rec., Geol. Surv. Ind.*, Vol. XXII, 149 (1889).
[2] *Rec., Geol. Surv. Ind.*, Vol. XXIII, 93 (1890).
[3] *Ibid*, Vol. XXVI, 113 (1893).

of gypsum bands, instancing a case at Ali Khan where a two-foot seam is so distorted that its outcrop has a seeming thickness of fourteen feet. Without venturing on an estimate he considered that there was a large amount of available coal within the field. In his opinion the best localities for mines, after the exhaustion of those at Khost, are at points $3\frac{1}{2}$ miles south-east of Sharigh, between Punja Ghat and Harnai and near Ali Khan.

The Khost Collieries, according to Griesbach,[1] are situated in a wedge of strata let down by a system of parallel faults. They have been established since 1877. The two seams worked have an average thickness[2] of 26 and 57 inches, but the principal seam now worked is from 22 to 26 inches in thickness. It is noncoking.

At Sharigh, where mines were worked between 1894-1896, and were again re-opened in 1910, the seams are, respectively, of an average thickness of $16\frac{1}{2}$ and 27 inches, the latter measurement including from 5 to 6 inches of shale. The thinner seam is the superior in quality. It has a caking quality. The dip of the strata averages about 50°.

In 1910 mining on a seam of coal 32 inches in thickness was commenced at Harnai.

The mines are the property of and are worked by the North-Western Railway Company, who appear to experience considerable difficulty in obtaining the requisite coolie labour. During the year 1910, 43,428 tons of coal were raised nearly all of which was used on the railway. The mines at work in that year are at Zardalu, Khost, Sharigh and Harnai.

Sor Range and Mach.—A number of thin coal-seams, associated with sandstones, occur in clay shales of middle eocene age in the Sor Range to the east and south-east of Quetta. The measures are widely distributed, but are much contorted and broken up by faulting, and obscured by landslips. The first locality in which they excited attention is Mach in the Bolan Pass where they are well exposed on the line of route, and have been long known to travellers.[3]

[1] *Op. cit.*

[2] James Grundy, Inspector of Mines in India: Report on the Khost and Sharigh coal mines, Calcutta (1896).

[3] Hutton, *Cal. Jour. Nat. Hist.*, VI, 570, 601 (1846).

In 1880 Griesbach [1] and a year later Blanford,[2] reported on inspections of the outcrops. Both observers noted the extreme disturbance of the rocks and considered the deposits too poor to be workable. The latter states that the principal seam varies from two feet four inches to two feet eight inches in thickness. He quotes the following analysis :—

Moisture	10·9
Volatile matter	33·1
Fixed carbon	41·0
Ash	15·0

The exposures were again examined in 1890, by R. D. Oldham [3] who mentions that the Mach mines have been worked fitfully for years and measured the following section at a point 2 miles south of Mach :—

Coal	1′ 3″	
Shale		1′ 10″
Coal	0′ 10″	
Strata		15′ 6″
Coal	1′ 11½″	
Shale		0′ 3″
Coal	0′ 2″	
Strata		6′ 10″
Coal	0′ 7″	
Shale		0′ 6″
Coal	0′ 3″	
Shale		0′ 3″
Coal	0′ 10″	
TOTAL COAL	5′ 10½	

Analysis of the coal from these seams approximated closely to that quoted above. Near the southern end of Bohr hill in a total of 3 feet 10 inches of strata, 2 feet 9 inches of coal was measured. This coal on analysis yielded 6 per cent. of ash.

At Digari in the Zharakhu valley, two seams are found. These vary in thickness from 2 feet 2 inches to 2 feet 11 inches and 2 feet 8 inches to 3 feet 3 inches, respectively. At the time of Mr. Oldham's visit they had been opened up at intervals over a length of 6,000

[1] *Mem., Geol. Surv. Ind.*, Vol. XVIII, 22 (1881).
[2] *Rec., Geol. Surv. Ind.*, Vol. XV, 149 (1882).
[3] *Report on the Coal Resources of Quetta*, etc., Calcutta (1891).

feet of outcrop. The average of two analyses of the coal gave :—

Moisture	7·7
Volatile matter	43·3
Fixed carbon	44·7
Ash	4·3

He estimated that in this area within 400 feet of the outcrop there are not less than 400,000 tons of coal, and probably much more than this amount.

The same seams were observed on the opposite (eastern) side of the range in the Astangi valley where they can be traced for miles. The measured thickness of four seams is 3 feet, 2 feet 10 inches, 2 feet and 2 feet, but they thin towards the north. Mention is also made of a coal mine at Gandak within 10 miles of Quetta, and of a coal-seam 2 feet 9 inches thick near Spin Karez about 13 miles from Quetta.

During the last twenty years a large number of small mines have been opened by petty contractors, but few of whom work on any regular system. They are chiefly situated within from 15 to 30 miles of Quetta and at Mach. Interesting reports on these mines [1] and on the mines at Khost and Sharigh [2] have been published by James Grundy, Inspector of Mines in India. The dip of the beds varies from 30° to 50° and the best seams average about 3 feet in thickness, but are very variable. The coal mined is of fair quality, but contains a considerable amount of sulphur as pyrites. During recent years an average quantity of 11,000 tons of coal has been mined annually, the output for 1909 being 12,212 tons. In 1911 mines were in operation at Digari, Mach and the Sor Range.

(vii). Bengal.

Burdwan District.—Owing to the recent territorial re-adjustment, only the eastern portion of the Raniganj coalfield remains in Bengal. It will be described with the remainder of the field under *Bihar and Orissa* (*infra* p. 43).

Darjeeling District.—The existence of coal-bearing rocks of Damuda age in this region was first recorded by Sir Joseph Hooker in 1849. They occur along the southern side of the Darjeeling synclinal as a narrow band varying from 200 yards to about a

[1] Calcutta, 1896 and 1899.
[2] Calcutta, 1896 and 1900.

mile in width and extending from Pankabari nearly as far as Dalingkot. This is doubtless the same belt of rocks as is found occurring in the Aka and Daphla hills on the north of the Brahmaputra.

Although subject to many minor contortions, the general dip of the rocks is to north-north-west at angles of from 40° to 90°; and as a result of the crushing to which they have been subjected the sandstones and shales have been frequently converted into quartzites and slates or even schists; whilst the coal has been crushed to powder and has lost a large proportion of its volatile matter, approximating to anthracite or graphite in composition.

In 1873-74 Mr. F. R. Mallet[1] examined the deposits and, after making a number of excavations and experiments in coking and briquetting the fuel, expressed the opinion that there was little hope of working the coal at a rate less than, or even at one not exceeding, that at which Raniganj coal could be laid down at the foot of the hills. The best seam discovered by Mr. Mallet outcrops near Tindharia, and is 11 feet in thickness. He found that only the coal from one locality was of coking quality.

In 1890 Darjeeling coal once more attracted attention and Mr. P. N. Bose[2] was deputed to the locality. His explorations were confined to an area $2\frac{3}{4}$ miles in length by $\frac{3}{8}$ mile in breadth situated between the Lisu and Ramthi rivers. A large number of thick seams were found and Mr. Bose calculated that 20 million tons of coal of good coking quality were available. Subsequently the same officer examined the entire Damuda area between Pankabari and the Tista river, but no further promising seams were discovered. The first and only attempt to work the coal on a commercial scale was undertaken by a Calcutta firm in 1896. A colliery was established at Daling and, until the abandonment of the enterprise in 1900, a total quantity of 7,231 tons of coal was raised.

The following analyses of the coal have been made in the laboratory of the Geological Survey of India:—

	Average of 5 samples.	Average of 8 samples.
Volatile matter	9·20	22·94
Fixed carbon	70·66	59·56
Ash	20·14	17·42

The occurrence of Gondwana coal-bearing rocks in the Himalayan foot-hills considerably enlarges the area over which these rocks

[1] *Mem., G. S. I.*, Vol. XI (1874); *Rec., G. S. I.*, Vol. X, p. 143 (1877).
[2] *Rec., G. S. I.*, Vol. XXIII, p. 237)1890); Vol. XXIV, p. 212 (1891).

are known to have been deposited; it has given rise to much speculation as to the probable existence of concealed coalfields beneath the alluvia of the Ganges and the Brahmaputra. The unknown, but great thickness of the alluvium and the difficulty which it would present to boring operations, together with the lack of indications for fixing upon the best sites for the holes, have, however, up to the present, deterred speculators from making search for such fields.

Tertiary lignites of no value have been examined in the sub-Himalayan rocks of the Tista valley by Dr. Oldham,[1] whilst Mr. Mallet[2] mentions two lenticular seams of soft flaky coal, one of which was as much as 6 feet thick in places but only extended for a few yards laterally. The quality of the fuel was inferior.

Baxa Duars.—Lignite has long been known to occur in the Baxa Duars, near Santrabari and Jaintia on the borders of Bhutan. The locality was visited in 1865 by Godwin-Austen[3] and later in 1897 by Hayden.[4] The lignite occurs as isolated logs in high-dipping Tertiary sandstones.

According to an analysis by Dr. Saise, it is of excellent quality having only a small percentage of ash. It, however, is found in too small quantity to be of any commercial value.

Chittagong.[5]—From time to time samples of brown coal or lignite from the Chittagong Hill Tracts have been received at the Geological Survey Office for examination and report. In no case have they been of a character to encourage a hope that coal occurs in sufficient abundance to be profitably worked. All the specimens received are believed to be of Tertiary age and probably come from the nummulitic rocks, which are known to form a portion of the hills, where, however, Cretaceous rocks also occur.

(viii). Bihar and Orissa.

Talchir,[6] *etc.*—The Talchir coalfield is situated in the valley of the Brahmini, which may be regarded as a tributary of the

[1] *Jour. As. Soc. Bengal,* XXXIII, 201 (1854).
[2] *Mem., Geol. Surv. Ind.*, XI, p. 46 (1874).
[3] *Jour. As. Soc. Beng.*, XXXIV, pt. 2, p. 106 (1865).
[4] *Rec., G. S. I.*, Vol. XXX, p. 249.
[5] *Manual Geol. India*, Vol. III, p. 111.
[6] Blanford and Theobald; *Mem., G. S. I.*, Vol. I, pp. 33, 38 (1856); Ball: *Rec. G. S. I.*, Vol. X, pp. 170, 173 (1877).

Mahanadi, since it anastomoses with it in the conjoined deltas. The area is about 700 square miles in extent. The groups represented have the following estimated thicknesses: Mahadeva, 1,500 to 2,000 feet; Kamthi and Barakar about 1,800 feet; Talchir, 500 feet. The Talchir stage received its name from this locality, a native state where it was first discriminated.

The coal is of inferior quality; one large seam at Gopalpersad is largely made up of carbonaceous shale, being similar to that to be described as occurring in Hingir. In assays which have been made of fair samples of the coal from the two principal seams at Patrapara, the fixed carbon did not exceed thirty per cent., while the proportion of ash ranged from 30 to over 40 per cent. In a practical trial at Cuttack of some of the Gopalpersad coal there was a residue of 34 per cent. of ash and clinker. The demand for coal in Orissa is too limited to render it probable that under present conditions of communication the field will ever be of much value.

Further to the south-east, partly in the Athgarh State and crossing the river not far from the town of Cuttack there is an area of sandstones and conglomerates in which fossil plants of the Rajmahal stage occur. It was at one time thought that these might overlie coal measures, but there is no sign of the characteristic coal measures anywhere on the margin of the deposits. Some black shales seen near Naraj encouraged the idea that coal would be found, but these really belong to the non-coal-bearing Rajmahal stage.

Rajmahal hills.—In this locality coal measures of Barakar age are exposed over 70 square miles; they doubtless extend, however, over a vastly greater area underneath younger formations. Separated by these overlying rocks five distinct areas or fields may be enumerated; 1. Hura; 2. Chaparbhita; 3. Pachwara; 4. Mhowagurhi; 5. Brahmini. These are all on the western margin of the hills. There is no continuity between the seams of these areas, and it will be an interesting and economically important point to decide whether the coal measures extend underneath the traps, etc., to the east. If so the total area of the deposits must be considerable and they would be close to the water carriage of the Ganges. A boring which was made in about 1885 with the object of finding out whether any coal occurred with some Barakar sandstones near Akbarnagar, north-west of Rajmahal, did not prove successful.

It was carried to a depth of 256 feet without getting through the supposed Barakar sandstone.

The coal-seams are thin, varying from 1 to 6 feet in thickness, and of inferior quality. The average analysis of samples from 13 localities is :—

Fixed carbon	42·13
Volatile matter	39·50
Ash	18·37

Ball [1] who examined the field in 1869-70, estimated that under the 70 square miles of exposed coal-measures there is a minimum thickness of 5 feet of workable coal, and a total quantity of 210 million tons of fuel, the whole of which lies at easily accessible depths. He adds that there is also a large amount of coal, much of which could be worked, lying beneath the trap.

Nearly 20 years later interest in the economic value of the field was revived and between 1888 and 1890 borings were put down by the Government of India acting under the advice of Dr. King,[2] Director of the Geological Survey of India. The experiments were confined to the Hura field where five borings were put down in the neighbourhood of old outcrop workings at Dakaiti, and further east at Semra. The greatest depth attained was 300 feet, and although two seams with respective thicknesses of 4 and 16½ feet were met with yet the inferior quality of the samples of coal obtained led to the abandonment of the exploration.

In 1908 Mr. M. Stuart [3] of the Geological Survey, drew attention to a coal outcrop at Gilhurria midway between the Hura and Dhamni fields, indicating the continuity of the coal beneath the trap. The quality was inferior.

In Dr. Oldham's Review [4] of Indian Coal Statistics for the period 1858-1868 returns are given of the output from these fields for the three years inclusive from 1858-1860. The most important mines were in the Hura field, where from two, Hura and Borah, a total of about 40,000 tons was extracted in the two years 1859-

[1] *Mem., G. S. I.*, Vol. XIII, 155 (1877).
[2] *Rec., G. S. I.*, Vol. XXII, 6 (1889) ; XXIII, 5 (1890) ; XXIV, 3 (1891).
[3] *Rec., G. S. I.*, XXXVIII, pp. 150-151 (1909).
[4] *Mem., G. S. I.*, VII, 149 (1869).

60. The next in importance were at Tesaphuli, in the Chaparbhita field, where about 16,500 tons were raised in the three years. Altogether it is probable that not more than 100,000 tons have been raised from these fields, and of that amount a large proportion was very poor stuff. A few quarries are still being worked for local purposes during the dry season, but the output for 1910 was only 2,788 tons.

Jainti, Sahajori, Kundit Kuraiah.—These three coalfields are situated in the south of the Sonthal Parganas, in the neighbourhood of the Adjai river. Their combined area is about 28½ square miles, of which 11½ square miles are occupied by Barakar rocks, the rest being Talchirs. The coal-seams are few in number and none attains a thickness of 3 feet. Samples from the Sahajori field, assayed by Dr. Waldie, contained from 28 to 37 per cent. of ash.

After an examination of the fields, Mr. Hughes[1] arrived at the opinion that they would never be of much importance owing to the poor quality of the coal they contain and the limited area over which it occurs.

In 1909 two mines were opened and worked for a short time. These were situated at Katmirki and Madancotta.

Giridih (Karharbari)[2].—This small but important coalfield is situated in the Giridih sub-division of the Hazaribagh district of Chota Nagpur, at a distance of about 200 miles from Calcutta by rail. It is of great importance, both on account of its position and the quality of its coal. The total area of the field is 11 square miles, of which 7 square miles are occupied by coal-bearing rocks (Barakars). Faults are numerous and some of them have great throw. There is a large number of igneous dykes, and their contact effects have destroyed many thousands of tons of coal. The most destructive are composed of mica-peridotite, whilst the widest are of basalt. There are many seams of coal, of varying thickness and quality, but the bulk of the workable coal is con-

[1] *Mem., G. S. I.*, VII, 247 (1870).
[2] Saise, *Rec., G. S. I.*, Vol. XXVII, 86 (1894); Holland, T. H. and Ward, T. H., *Trans., Min. Geol. Inst. of India*, I, part 3, pp. 193-198 (1907).

Photo by R. R. Simpson.

G. S. I. Calcutta.

tained in the Karharbari Lower Seam, which has an average thickness of 15 feet 4 inches and the following composition :—

Volatile matter	24·42
Fixed carbon	66·84
Ash	9·15

Of recent years this is the only seam which is being mined to any extent.

The Upper Karharbari seam has an average thickness where workable of 6 feet and is of good quality. The workable area, however, was only some 150 acres, and the seam is now almost exhausted. Of the Upper or Hill seams the principal is the Bhaddoah Seam, which is found over an area of 913 acres. About 400 acres are of sufficiently good quality to be worked. The average thickness is 6 feet and where it was largely worked the composition is :—

Volatile matter	22·51
Fixed carbon	60·85
Ash	15·84
Sulphur	0·80

Of the rest of the Hill seams the average aggregate thickness is 66 feet and they extend over an area of some 200 acres. The ash in these seams, however, varies from 13 to 55 per cent., and probably only about one quarter of the total amount of coal is of sufficiently good quality to be workable.

From time to time various estimates of the quantity of workable coal contained within the field, have been made, the latest and probably most reliable, being by Dr. Saise, who calculated that in 1894 there were 82½ million tons of coal which might be profitably extracted. Since that time 12 million tons have been mined, the output for 1910 being 679,304 tons, or about 12 per cent. less than the average for the preceding five years.

The seams are very favourably situated for working owing to their usual low angle of dip, their accessibility—the deepest coal lying within 900 feet of the surface,—and the comparatively small amount of water contained in the rocks.

Coal has been mined at Giridih since 1857, but railway connection was not established until 1871, since which date vigorous

development has taken place. The principal mine operators in the field are the East Indian Railway Company, and the Bengal Coal Company, the former company raising by far the largest amount of coal.

In this field scientific methods of mining and management have probably reached a higher pitch of development than in any other Indian coalfield. The most improved modern machinery is employed. Coal cutting by machinery, mechanical screening, briquetting, coke-making in closed ovens have been practised for some years, and appliances for the conservation of the valuable bye-products,[1] formerly lost in the process of manufacture, are now in successful operation. The following are analyses [2] of Giridih coal made by the Simon Carves Company, a well-known firm of coke-oven builders :—

			No. 1 Sample (wet coal).			No. 2 Sample (wet coal).		
Volatile matter.	Ammonia water.	Moisture 1·77	3·44	23·28	1·01	1·91	23·56
	..	Water of condensation 1·67			0·90		
	Tar	..	5·89			7·54	
	Gas and Loss.	..	13·95	..	..	14·11	..
Coke	Fixed carbon	..	61·86	76·72		64·37	76·44
	Ash	..	14·86			12·07	

In both cases the coke was good and without breeze; the assay in the crucible on the dry coals gave respectively 76·21 per cent. and 74·6 per cent. of coke.

	No. 1 sample (wet coal).		No. 2 sample (wet coal).
Gas (in volume) . .	per ton 9,764 c. ft.		10,124 c. ft.
Ammonia (by weight) .	„ „ 6·77 lbs.		6·98 lbs.
Equivalent in sulphate of ammonia.	„ „ 26·33 „		27·1 „
Benzole (at 150°) . .	„ „ 8·4 „	(=·935 gals.).	7 lbs. (=·7 gals.)
Ferro-cyanide of sodium	„ „ 1·14 „		·083 „

[1] Ward, T. H., *Trans., Min. Geol. Inst. of India*, IV, pp. 351-359 (1910).
[2] *Rec., G. S. I.*, XXXI, 102 (1904).

R. R. Simpson, Photo.

G. S. I., Calcutta.

COLLIERY, GIRIDIH

The system of mine inspection at Giridih and the measures taken to provide for the safety of the workmen are probably equal to the best mining practice of Europe. Whilst the excellent housing accommodation, the facilities for the acquisition of small parcels of land by the workmen, and the establishment of excellent and well-attended schools and well-equipped hospitals reflect the greatest credit upon the engineers engaged in the development of the coalfield.

Raniganj.[1]—The Raniganj field is the largest of the coal-fields now being worked in India. It is situated from 120 to 140 miles north-west of Calcutta, and the East Indian Railway Company's line passes through it centrally. The Bengal-Nagpur Railway Company also have access to the coalfield, and besides these trunk lines there is a growing net-work of branch lines and sidings for the service of the collieries.

The extent of the exposed coalfield is approximately 500 square miles, within which area the Panchet, Damuda and Talchir groups attain an aggregate thickness exceeding 11,000 feet. The general dip of the beds is towards the south at angles of from 5° to 20° and the measures are abruptly cut off at the southern boundary by a fault the throw of which must, at the least, be equal to the full thickness of the beds. On the east the coal measures dip under the Gangetic alluvium, and the boundary of the field is unknown. Recent borings, however, point to their extension eastwards to a very great distance, but overlain by the higher beds of the series, and at a considerable depth. There are numerous faults and dykes, most of which are obscured by the alluvial cap which covers so much of the coalfield, so that their presence is, as a rule, only disclosed during the course of mining operations. Much remains yet to be done in the unravelling of the fault structures and the correlation of the coal-seams, and a special committee of members of the Mining and Geological Institute is at present engaged upon this work, and will shortly publish a revised edition of Dr. Blanford's original map of the coalfield. The dykes are of mica-peridotite and basalt. The principal intrusion is the great Salma basaltic dyke, which has a thickness of 120 feet, and

[1] Blanford: *Mem., G. S. I.*, III, Art. 1 (1863).

has been traced for 20 miles. An enormous amount of coal has been rendered worthless by these igneous intrusions.

Coal-seams are found in both the Barakar and Raniganj subdivisions of the Damuda series; these groups being separated from one another by the Ironstone Shales. According to Blanford, in the Barakar beds, four seams with an aggregate thickness of 69 feet have been worked, and in the Raniganj stage, 10 seams with an aggregate thickness of 110 feet, whilst many other seams are known to occur within the field. Presuming that an average thickness of 50 feet of workable coal occurs throughout the area of 400 square miles occupied by the coal-bearing rocks, and that the average specific gravity of the fuel is 1·393,[1] the total quantity of coal within the field would be 21,671 million tons. Closer estimates of the quantity of coal from the best seams now in sight are given below.

By far the greater portion of the output of coal is drawn from the Raniganj or Upper measures and the major portion of this from two seams—the Dishargarh and Sibpur seams. Other seams of importance are the Sanctoria, Ghusic and Raniganj seams.

In the Barakar or Lower measures no one seam can be traced for any considerable distance, but thick seams are worked at about the same horizon at Laikdih, Ramnagar and Salanpur. Good coal is also worked at Begunia near Barakar, at Borreâ and at Gaurangdi.

A fault with a throw of several hundreds of feet traverses the coalfield from north to south and divides it roughly into two halves. Parallel with this fault, but about a mile to the west, the great basaltic intrusion known as the Salma dyke can be traced right across the field and into the crystalline rocks in both directions. These structural features appear to have profoundly affected the coal seams, and correlation between the seams on either side of the break is difficult. Another pronounced fault with a parallel direction and even greater throw can be traced between Ikrah and Raniganj. Correlation of the seams on either side of this fault is again very uncertain. There is a marked deterioration in the quality of the coal passing from west to east, and it is a fair generalization to say that there is no first class coal worked east of this fault.

[1] *Rec., G. S. I.*, X, 156 (1877).

The following are typical sections across the coal measures :—

Section from Damuda river near Sitalpur to Ramnagar.

	Feet.	Feet.
Strata with thin coal seams		550
Dishargarh seam	16	
Strata		286
Hatnal seam	8	
Strata		138
Sanctoria seam	10	
Strata		200
Jasaidih seam	3	
Strata		200
IRONSTONE SHALES		900
Chanch-Begunia seam	10	
Strata		700
Ramnagar seam	12	
Strata		100
Laikdih seam	80	

Section from Asansol to Chinchuria.

	Feet.	Feet.
Nursumuda seam	4	
Strata		350
Gopalpur seam	4½	
Strata		210
Borachuck seam	10	
Strata		320
Coal seam	11	
Strata		500
Raghunâth Bâti seam	4½	
Strata		100
Borodhemo seam	10	
Strata		400
Dishargarh seam	8—12	
Strata		400
Sanctoria seam	9	

Section from Joba to Sibpur.

	Feet.	Feet.
Joba (Poriharpur ?) seam	14	
Strata with thin coal seams . . .		650
Koithi seam	12	
Strata		130
Sibpur (Sanctoria ?) seam	16	
Strata		100
Taltore seam	3½	
Strata		200 ?
IRONSTONE SHALES	..	

Section at Raniganj.

	Feet.	Feet.
Searsole seam	18	
Strata		180
Raniganj or *Jamehari seam* . . .	18	
Strata		70
Narrainkuri or *Nimcha seam* . . .	12	
Strata		500 ?
Raghunathchak seam	14	
Strata		?
Kalikapur seam	10	

Section between the Damuda and Adjai rivers commencing north of Ondal.

	Feet.	Feet.
Babisole seam	14	
Strata		60
Madhabpur seam	16	
Strata		200
Sonachora seam	9	
Strata		100
Bowla or *Mangalpur seam*	30-42	
Strata		100
Bunbehal seam	14	
Strata		100
Chora or *Kenda* or *Toposi seam* . . .	27	
Strata		120
Dobrana or *Chowkidanga seam* . . .	18	
Strata		90
Dhosal seam	8	
Strata		100
Sonpur seam	5-20	
Strata		
Kendra or *Samla Seam*	16	

G. S. I. Calcutta.

R. R. Simpson. Photo.

NCLINE, DISHARGARH COLLIERY.

The most important seam in the coalfield is the Dishargarh seam. It has an average thickness of 18 feet and can be traced from Nodiha, south of the Damuda river, in a north-easterly direction for about 12 miles to Nuni, 4 miles north of Asansol. East of Sitarampur, however, the coal is much damaged by trap intrusions.

The Sanctoria seam is 10 feet thick. Except in the neighbourhood of Sanctoria itself it has not been much worked. Around Sitarampur the outcrop is completely burnt by trap. The seam is probably workable between Sanctoria and Sodepur, a distance of about 2 miles.

The Sibpur seam ranks second in importance in the coalfield. It is from 12 to 18 feet in thickness and can be traced from Chinchuria, 4 miles north of Asansol to Ikrah Junction, East Indian Railway, a distance of about 9 miles.

The Ghusic seam is 12 feet in thickness and preserves its valuable quality for a distance of about 3 miles in the neighbourhood of Kalipahari.

The Raniganj seam is 15 feet in thickness and, as its name implies, is found in the neighbourhood of Raniganj. About 2 miles of outcrop have been proved.

The workable seams of the Barakar or Lower measures at Chanch, Laikdih, Ramnagar and Salanpur may be considered to average 20 feet in thickness and to have a length of outcrop of 10 miles.

Presuming that these seams can all be profitably worked to a distance of 2 miles from the outcrops toward the dip, and deducting one-third for coal already extracted or unworkable the amount of coal available would be :—

First class coal.—	
Dishargarh seam	300 millions of tons.
Sanctoria seam	30 ,, ,,
Sibpur seam	188 ,, ,,
Total quantity of first class coal .	518 ,, ,,
Medium quality coal.—	
Ghusic seam	50 millions of tons.
Raniganj seam	40 ,, ,,
Laikdih-Salanpur seam	270 ,, ,,
Total quantity of medium quality coal .	360 ,, ,,

The quantity of coal usually described as second class is practically inexhaustible and can be calculated in thousands of millions of tons.

From the above figures it can be seen that at the present rate of output there is not more than 100 years' supply of first class coal available at a moderate depth.

As the mines increase in depth increasing quantities of inflammable gas are being encountered, and at certain collieries safety lamps are used throughout the whole of the workings. Most of the seams are liable to spontaneous combustion and large areas of coal have been lost as the result of fires (Plate 8).

The coal is a hard, dull to bright black substance, occurring in seams composed of alternating laminæ of bright, jetty and dull shaly coal, and containing a well-defined cleavage. It is bituminous, but only the coal from certain seams has good coking qualities. It contains from 10 to 15 per cent. less fixed carbon than coal from Giridih or Jharia. The best coal is found in the lower seams of the Raniganj series, particularly at Sanctoria, Dishargarh and Sibpur. As a rule the quality of the coal in the very thick seams, particularly in the lower measures, is inferior to that from the thinner seams. The average analysis of 31 samples analysed by Mr. Tween[1] in 1870-73, is :—

Moisture	4·30
Volatile matter	25·83
Fixed Carbon	53·20
Ash	16·17

The analysis is interesting in that it shows the quality of the coal then worked.

More recent analyses by Dr. Saise[2] gave the following summarized results :—

Series.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	REMARKS.
Raniganj (upper seams)	6·99	32·30	49·28	11·43	Average of 7 samples.
Do. .	6·64	32·06	40·25	21·05	Average of 4 samples.
Raniganj (lower seams)	3·79	31·76	52·94	11·51	Average of 20 samples.
Do. .	3·74	31·26	46·41	18·59	Average of 8 samples.
Barakar . . .	1·12	25·13	59·75	14·00	2 samples from Chanch and Laikdih.
Do. . . .	1·00	26·80	52·69	19·51	Average of 5 samples.

[1] *Rec., G. S. I.*, X, 156 (1877).
[2] *Rec., G. S. I.*, XXXI, pp. 104-107 (1904).

Fig. 1. UNDERGROUND FIRE, CHARANPUR COLLIERY, RANIGANJ COAL-FIELD.

R. R. Simpson, Photo. *G. S. I., Calcutta.*

Fig. 2. BURNING COAL SHAFT, CHARANPUR COLLIERY, RANIGANJ COAL-FIELD.

As Dr. Saise points out, one of the most interesting facts brought out by this table of analyses is the notable increase in the percentage of moisture as we pass from the lower to the higher series. This takes place side by side with an equally marked decrease in the percentage of fixed carbon.

An elaborate series of analyses and calorific values of "Bengal" coals was published by Major F. C. Hughes[1] in 1910. The following is a summary of the results for the Raniganj field :—

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Calorific value stated in calories.	
					Calculated.	By experiment.
Raniganj or Upper Measures (22 samples).	4·76	32·16	53·42	9·66	6,835	6,767
Barakar or Lower Measures (3 samples).	1·65	24·76	64·05	9·54	7,571	7,348

The earliest attempt at coal-mining in the Raniganj field appears to have been made in 1812, but little profitable work appears to have been done until 1843, when by the amalgamation of two of the leading firms in the field, the Bengal Coal Company was formed. This company has continued to mine coal since that date, and for the past 60 years has been the largest colliery proprietor in the field. In 1854, the East Indian Railway reached the field, and considerable expansion in the coal trade naturally resulted. In 1860, the produce of the 42 collieries being worked in the Raniganj field was 281,994 tons of coal, whilst in 1910 the output was 4,212,606 tons and the number of collieries had increased to 206.

Jharia.—That the existence of coal in this locality has been long known is shown from the fact that in 1777 a proposition was made to Government by Messrs. Farquhar and Motte [2] to be allowed to cast shot and shell in the field.

The Jharia coalfield is the most important of the recently developed coalfields in India. It is situated 16 miles west of the Raniganj

[1] *Trans., Min. Geol. Inst. of India,* V, pt. 2, pp. 114-180 (1910).
[2] *Jour., As. Soc. Beng.,* XI, 822 (1842).

field. It is roughly elliptical in shape, and has a maximum length, east and west, of about 23 miles, the greatest breadth being about 10 miles. The total area of the coal-bearing rocks (Damudas) is about 150 sq. miles. The beds have been deposited in the form of a basin, the rocks dipping towards a common centre at angles of about 10°. High dips, however, prevail on the southern margin of the field, where the boundary is abruptly faulted. The thickest and best coal seams occur among the Barakar beds, in which 18 seams, varying in thickness from a few feet to as much as 100, have been discovered. In the Raniganj series there is a number of thin seams, but they are inclined at high angles, and Hughes,[1] who explored and mapped the field in 1865, pronounced them to be worthless. Subsequent working has shown that at least one of these upper seams is of valuable quality.

Three typical sections across the coal measures are given below :—

Jharia section.

No. of seam.	Coal in feet.	Strata in feet.
18	13	..
		130
17	7½	
		300
16	14	
		240
15	23	
		14
14 A	7½	
		80
14	26	
		70
13	6	
		10
12	10	
		22
11	11	
		120
10	45	

[1] *Mem., G. S. I.*, V. pt. 4 (1866).

R. R. Simpson, Photo.

HANKSIMULA COLLIERY RANIGANJ COAL FIELD

G. S. I., Calcutta.

The seams below No. 10 are of poor quality and are practically unworked.

Section between Katras and the Jamuni river.

No. of seam.	Thickness in feet.	Remarks.
18	4½	
17	3½	
15 Bottom	4½	
15 Top	7	
14	14	
13	8	
12	15	
11	16	
10	14	
9	8	
8 A	5	
8	8	
7	14	
6	5	Seen in bank of Jamuni River.
5	14	
4	20	Not worked
3	20	
2	7½	
1	100 (10′ good)	

Section across the Upper measures at Murulidih.

Name of seam.	Coal in feet.	Strata in feet.
Top	6	Not much worked.
		200
Middle	8	Do.
Bottom	9	28

The most recently published estimate of the quantity of coal within the field was made in 1890 by T. H. Ward,[1] who calculated that in seams Nos. 12 and 13 with thicknesses of 11½ and 5 feet respectively, there are nearly 1,287 million tons of coal. Since then mining operations have proved the value of Nos. 10, 11, 12, 13, 14, 14A, 15 16, 17 and 18 seams with an aggregate thickness of more than 150 feet, about half of which is of first class quality. It is difficult, however, to give even an approximate estimate of the coal available, for recent sinkings and borings in the richest part of the field, *i.e.*, between Bhulanbarari and Balliari, have proved that much of the coal to the dip of the collieries now being worked is burnt and valueless. It is to be hoped that valuable stores of fuel exist to the dip of the burnt zone, but so far as is known at the present time the extent of the burnt areas increases with the depth.

Presuming that an average thickness of 100 feet of coal is workable to a depth of 500 feet between Bhulanbarari and Katras (about 12 miles) the amount of coal would be 840 millions of tons. Of this quantity only about 6 per cent. has been already mined. If half the estimated quantity be considered of first class quality it appears that within the limits given above there is not more than 100 years' supply of first class coal. As in the Raniganj coalfield there are vast stores of coal of second class and lower grade quality. There is a marked deterioration in the quality of the coal on the west of the coalfield, and there is no colliery of importance being worked west of Katras.

Besides the great fault forming the southern boundary of the field there is a number of minor faults coursing chiefly in a direction

[1] *Rec., G. S. I.,* XXV, 110 (1892).

R. R. Simpson, Photo. G. S. I. Calcutta.

CHARANPUR COLLIERY, RANIGANJ COAL-FIELD

parallel to the strike of the measures. Some of them, as on the west of the Jamuni, have considerable throw and render difficult the correlation of the coal seams.

As in the Giridih and Raniganj fields dykes of mica-peridotite and basalt are common. The former are especially destructive and their evil effects on the coal as referred to above are more pronounced in this than in the above-mentioned coalfields.

The coal resembles the Raniganj coal in appearance and much of it is perhaps superior in quality to the majority of the seams in that coalfield. Several of the seams furnish coal of good caking quality, that from Nos. 15, 14 and Bhowra A seams being perhaps the most valuable for the manufacture of coke. The average analysis by Ward of four samples from seams Nos. 12 (two samples), 13 and 17, is :—

Volatile matter	29·14
Fixed carbon	59·30
Ash	11·56

The following assays[1] of coal and coke were made in 1902 of samples selected by Mr. W. Jones, acting for Messrs. E. P. Martin and Professor H. Louis.

The samples were cut uniformly across the working face of the seams, and they are consequently not open to the usual objection made against samples taken from a particular part of a seam :—

No. of seam.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	lbs. of water evaporated by 1 lb of coal.	REMARKS.
17 . .	1·40	26·54	59·76	11·77	0·53	12·91	
15 . .	0·83	21·79	65·01	11·92	0·46	13·18	Average of 4 samples.
14 . .	0·69	18·60	69·68	10·50	0·53	13·61	Average of 3 samples.
14 . .	1·06	20·01	55·80	22·57	0·56	12·27	One sample.
13 . .	1·08	20·00	62·69	15·64	0·59	12·74	Average of 2 samples.
12 . .	0·92	22·02	55·9[illegible]	20·50	0·63	12·47	One sample.
12 . .	1·14	21·65	62·28	14·20	0·73	13·16	One sample.
11 . .	0·68	19·56	57·39	21·75	0·62	11·96	One sample.
Bhowra A .	0·78	26·22	65·99	7·01	..	..	One sample.

[1] *Rec., G. S. I.*, XXXI, pp. 238-239 (1904).

Four samples from seams Nos. 17, 15, 14 and 13 yielded an average of 0·175 per cent. of phosphorus. Of 9 samples of coke analysed for the same gentlemen the average percentages of sulphur and phosphorus were 0·66 and 0·17, respectively.

The above analyses are of samples from coal seams all of which occur in the Barakar series, and it is interesting to note that the low percentage of moisture, noticed by Dr. Saise, in the coal of the Barakar series in the Raniganj field, is characteristic also of the Barakar coal in the Jharia field. That there is a correspondingly high percentage of moisture in the coal from the Raniganj series is shown from the following analysis[1] of the Murulidih A seam. Where sampled the seam is nine feet in thickness, and successive samples were taken from each foot of thickness, the first foot which contains more than 20 per cent. of ash being discarded :—

Moisture varies from	2·72 to 3·80 and averages		2·96
Volatile matter varies from	26·16 to 31·00	,,	29·60
Fixed carbon varies from	51·36 to 57·26	,,	53·71
Ash varies from	11·84 to 15·24	,,	13·73

The analyses of Jharia coal summarized below were made by Major F. C. Hughes[2] in 1909 :—

	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Calorific value stated in calories.	
					Calculated.	By experiment.
Raniganj or Upper Measures (2 samples).	1·68	30·62	57·26	10·45	7,183	7,195
Barakar or Lower Measures (22 samples).	1·25	23·21	63·77	11·78	7,481	7,197

Until recent times it was commonly supposed that fire-damp did not occur in the coal seams of this field. As the workings have increased in depth, however, gas has made its appearance at a number of mines. At one mine in the upper measures safety lamps are used throughout.

Another danger which was thought to be absent from the mines is that of spontaneous combustion. In 1911, however, serious fires

[1] Lala Hira Lal, *Geol. Surv. Ind., Lab. Records* (1901).
[2] *Trans., Min. Geol. Inst. of India,* V, pt. 2, pp. 114-180 (1910).

from this cause broke out at two well-known collieries. Smaller fires have also been experienced at other mines.

The great thickness of some of the best coal seams adds considerably to the difficulty of working for not only does it militate against a high percentage of extraction, but it also introduces serious danger from falls of coal from the lofty pillars formed in the customary method of working. At a number of mines this difficulty is being successfully met by a system of working in stages with an unworked layer of coal between the successive stages. At one mine where a seam 100 feet thick dips at an angle of 45° a system of working in horizontal slices has been introduced and promises to be a success.

By the extension of the East Indian Railway Company's Barakar branch this coalfield first obtained railway connection in 1894, in which year 15,000 tons of coal were produced. In 1903 the Bengal-Nagpur Railway Company extended their lines into the field, and the two railway companies will eventually take each about equal portions of the coal traffic. In 1910, 193 collieries were at work and the output was 5,794,534 tons of coal or about one half of the whole production of India. The expansion during the decade 1899-1908 was almost ninefold, and in 1906 the production outstripped that of the neighbouring Raniganj field, and the Jharia field assumed the lead and became the largest producer of coal in the Indian Empire.

Bokaro.—The Bokaro coalfield lies some two or three miles west of the termination of the Jharia field. Its greatest length is in an east and west direction and is about 40 miles; its maximum breadth from north to south does not exceed 6½ miles. The total area is 220 sq. miles.

The rocks represented range from Talchirs to upper Panchets and are much disturbed by faulting; high dips being the rule rather than the exception. Although coal-seams are found in the Raniganj beds, yet the whole of the workable coal occurs in the Barakars. In the opinion of Mr. Hughes[1] who mapped the area in 1866 the coal cannot be compared in its general quality with that obtained from the Jharia coalfield. The number of coal-seams is very large and some of them are enormously thick. In many places they have been much damaged by intrusions of trap.

[1] *Mem., G. S. I.*, Vol. VI, p. 58 (1867).

The most productive portion of the field lies between the Kunar river and the eastern boundary. Among several thick seams of good quality in this latter area, one measuring 88 feet in thickness stands pre-eminent. In the same locality the dips vary from 5° to 10° and the ground is, therefore, much more favourable for working than in other parts of the field.

Mr. Hughes mentions 1,500 million tons as the probable amount of available fuel which the field can yield. A few workings have been made on the outcrops of the seams for the purpose of supplying coal to the civil station of Hazaribagh. Although the inferiority of much of the fuel and the cost of transport would cut it out from the Calcutta market, yet now that the railway companies are extending their lines to the west of the Jharia field it is not unlikely that the opening of a limited number of mines for the supply of coal to up-country markets would be a successful commercial venture. During the coal boom of 1907 a large amount of prospecting work was done by firms interested in the field, but no details are yet available for publication. In 1910 four collieries were at work and 2,166 tons of coal were got. The Bengal-Nagpur Railway Company is now engaged in building a line to this coalfield.

Ramgarh.[1]—This coalfield is situated in the Hazaribagh district of Chota Nagpur. It lies along the valley of the Damuda river some 5 miles to the south of the Bokaro coalfield. Its area is about 40 sq. miles. The rocks exposed have a total thickness of more than 5,000 feet and consist of Damudas and Talchirs. The rocks of the Barakar stage contain a large number of thick coal-seams, of which some are of fair quality, but much disturbed; on the east where low dips prevail the coal is very inferior.

Ball[2] estimated that about 5 million tons of coal are available, but did not think it probable that the coalfield would ever be worked to any great extent. It is believed that small quantities of coal have been worked by the natives and carried to Ranchi for sale.

North and South Karanpura.—These extensive coalfields occupy the head of the Damuda valley and lie at the base of the southern scarp of the Hazaribagh table-land, from one to four miles west of the Bokaro and Ramgarh coalfields. Their respective areas are 472 and 72 sq. miles. Although separated from one another by

[1] Ball: *Mem., G. S. I.*, Vol. VI, p. 109 (1867).
[2] *Manual*, Vol. III, p. 84 (1881).

a strip of their common gneissic floor, from one half to three miles in width, for all intents and purposes they form one field.

The rock groups represented within the area are the same as those which occupy the easterly fields of the Damuda valley, *i.e.*, Panchets, Damudas and Talchirs. The structure of the field is that of a comparatively shallow and somewhat oval basin, or broad synclinal trough, with a general dip inwards of the strata from all parts of the periphery towards the centre; but it is not exempt from local undulations. Except for the well-defined fault on the south of the fields, dislocations of the strata are few and unimportant. There is an extraordinary absence of trappean intrusion and with the exception of two in the southern field the dykes which are seen are not traceable for any distance. There is a number of thick coal-seams but they are much less numerous than in the eastern fields. Mr. Hughes[1] who mapped the area in detail in 1867-68 estimated that in the northern field, presuming an average thickness of 35 feet of coal to occur over an area of only 250 sq. miles, there is a total quantity of 8,750 million tons of coal. In the southern field he assumed an average thickness of 50 feet of coal over an area of only 15 sq. miles, and a total quantity of 75 million tons of coal. Mr. Hughes points out that these estimates are extremely conservative ones. Much of the coal is of excellent quality; the following assay is a fair measure of the quality of the better seams :—

Volatile matter	27·00
Fixed carbon	64·50
Ash	8·50

The position of the coalfields between the elevated table-lands of Hazaribagh and Ranchi render them somewhat difficult of access. In time to come, however, the construction of the projected Jharia-Daltonganj line, *viâ* the Damuda valley, will afford them communication with both up and down-country markets. From the latter the heavy freight charges would probably keep out the coal until such time as the better coals of the lower coalfields become exhausted; in the former market, however, Karanpura coal would probably be in considerable demand at highly remunerative prices.

Chopé.—This small coalfield is situated on the Hazaribagh plateau at an elevation of 2,000 feet above sea-level, and lies about

[1] *Mem., G. S. I.*, Vol. VII, p. 285 (1871).

8 miles a little north of west from the civil station of Hazaribagh. It consists of Talchir and Barakar rocks and has an area of about three-fourths of a sq. mile. There is only one coal-seam with a thickness of about 4 feet but it is found over a very small portion of the area and is of poor quality. Ball [1] considered that some of the coal might be made use of locally for brick and lime-burning.

Itkhuri.—At a very much lower elevation and nearly 20 miles north of the Chopé field another small area of Talchir-Barakar rocks is found on the Mohoni, a tributary of the Gya river. The Barakars occupy only about $\frac{1}{2}$ a sq. mile, or $\frac{1}{45}$th of the area. They contain three seams of coal of from 4 to 8 feet in thickness, but the quality is inferior, the average coal containing more than 30 per cent. of ash. Hughes [2] estimated that from $1\frac{1}{2}$ to 2 million tons of coal were available, but did not predict its use for more than lime and brick-burning purposes in the locality.

Auranga.—This field lies some 6 miles west of the Karanpura field and is situated in the valley of the Auranga river, a tributary of the Koel, which itself flows into the Son. It is within the boundaries of the Palamau district of Chota Nagpur. It has an area of 97 sq. miles and the rock groups represented range from the Mahadevas to the Talchirs, with a total thickness of 4,500 feet. The shape of the area is extremely irregular owing to the numerous dislocations of the rocks which have taken place. There appears to be an absence of trap intrusions. The whole of the workable coal is confined to the Barakars which cover an area of $58\frac{1}{2}$ sq. miles, and contain numerous coal-seams, some of which are of great thickness. In the sections exposed, however, the quality is, as a rule, inferior; the average analysis of 6 samples from different localities is as follows:—

Moisture	7·00
Volatile matter	28·50
Fixed carbon	36·50
Ash	28·00

It has been estimated [3] that about 20 million tons of coal of the quality indicated by the above analysis are available.

[1] *Mem., G. S. I.,* Vol. VIII, p. 347 (1872).
[2] *Mem., G. S. I.,* Vol. VIII, p. 321 (1872).
[3] Ball: *Mem., G. S. I.,* Vol. XV, pp. 1-127 (1878).

Hutar.[1]—This field is situated in the valley of the Koel river about 12 miles to the west of the Auranga field; it has an area of 78½ sq. miles, of which 57 are occupied by the coal-bearing Barakars. Faults are much less in evidence than in the Auranga field and the prevailing dips are at low angles; the only trap intrusions known are confined to the Talchir rocks. There are several coal-seams, but only three are of such a thickness and quality that they could be worked with profit; these are as follow:—

Dauri river, S. E. of Harilong	8′ 0″ seam.
Hurtah river, at Toleh	8′ 0″ ,,
Supahi river, at Binda	13′ 8″ ,,

The last mentioned seam contains only a small quantity of coal, a fault bringing up the gneiss within a few feet of the outcrop. The lack of continuous exposures renders it unwise to hazard any estimate of the quantity of coal; but with the evidence at disposal the prospects of the field do not appear to be encouraging. The quality of the coal is well up to the average of Indian coals; the average analysis of 8 samples is as follows:—

Moisture	5·95
Volatile matter	28·00
Fixed carbon	55·35
Ash	10·70

Daltonganj.—The Daltonganj field is situated in the valleys of the Koel and Amanat rivers in the Palamau district of Chota Nagpur. The total area of the field is nearly 200 sq. miles, but the coal-bearing rocks (Karharbari Barakars) occupy only about 30 sq. miles of this area. The distribution of the coal appears to be extremely irregular, and there is apparently only one seam from which hope of extracting any large amount of coal may be entertained. The maximum ascertained thickness of this seam near Rajhara is 29 feet but it thins out more or less rapidly in all directions. Various estimates have been made of the amount of workable coal in the field. In 1869 Mr. Hughes[2] fixed this amount at 18 million tons, but Dr. Saise in 1890 estimated that there was a total quantity of 161,377,000 tons of coal containing 11·7 per cent. of ash. In 1891, however, a number of borings

[1] Ball: *Mem., G. S. I.*, Vol. XV, pp. 1-127 (1878).
[2] *Mem., G. S. I.*, Vol. VIII, p. 325 (1872).

were put down under the supervision of Mr. La Touche, and with the evidence thus obtained, the latter considered that not more than 9 million tons of coal could be safely counted upon. The following assays of Daltonganj coal have been published :—

—	PANDUA.[1]	SINGRA(?)[1] Average of 2 samples.	RAJHARA.[2] Average of 2 samples.	RAJHARA.[2] Average of 2 samples.
Moisture	..	8·10	4·50	8·40
Volatile matter	22·4	28·80	18·89	27·63
Fixed carbon	64·2	53·10	34·56	49·37
Ash	13·4	10·00	42·05	14·60

Between 1842 and 1862, collieries were worked at Pandua and Rajhara, chiefly by the Bengal Coal Co., who apparently extracted a considerable amount of coal, which they sent down the Koel river to the Ganges during the rains. In 1901, when the field received railway connection, the same company resumed the working of the mines. The output for the year 1910 was 84,996 tons.

(ix). Bombay.

Sind.[3]—In the oldest Tertiary (lower eocene) rocks of Sind which have been named the Ranikot beds by Dr. Blanford, traces of lignite have from time to time attracted notice; but in only one instance has anything more than a mere layer of a few inches been detected. The locality in question is Lainyan (Lynan or Leilan), 27 miles north-north-west of Kotri, and 15 miles from the right or western bank of the Indus. In the year 1857, a shaft was sunk to a coal seam 5 feet 9 inches in thickness; but on driving out galleries the seam dwindled down to nothing while at the outcrop there was only a thin layer of carbonaceous shale. Dr. Blanford after paying a visit to the locality reported[4] that the deposit did not extend in workable form for a stone's throw in any direction whatever. The fuel is said to be extremely brittle and abounding in pyrites.

Lainyan.

[1] *Mem. G. S. I.*, Vol. VIII, p. 325 (1872).
[2] *Rec., G. S. I.*, Vol., XXIV, p. 141 (1891).
[3] *Manual, Geol. Ind.*, III, p. 95.
[4] *Mem., G. S. I.*, Vol. VI, p. 14 (1867).

Cutch.[1]—As early as 1834, if not before it, hopes were entertained that coal seams of good quality and workable thickness would be found in the Jurassic rocks of Cutch. Captain Grant, R.E., after carrying on mining explorations for some time was, however, compelled to report that the seams had not been found of workable thickness and the coal was mostly slaty and incombustible. A few thin layers of carbonaceous shale were noticed by Mr. Wynne[2] as occurring in the Tertiary rocks, but they were not considered to be of economic importance. The most important of Captain Grant's trials was made at Trombow, about 5 miles to the north-east of Baj. The old workings at this place were examined by Dr. Blanford,[3] who found that the seam was 16 inches thick, of which only half was good coal.

Trombow.

Carbonaceous shale with coaly layers is said[4] to occur in the river north of Sisagadh; there is, however, no workable seam and the coal is excessively brittle.

Sisagadh.

Coaly shale, of which 2 feet were visible, is reported[4] to occur in a stream west of Guniri, near Lakpat.

Guniri.

Kathiawar.—The occurrence of thin strings of coaly matter in a band of carbonaceous shale of Jurassic age near Than, north of Chotila, has given rise to frequent reports of the existence of coal in Kathiawar. Mr. Fedden,[5] who examined the deposits in 1883, has stated that it is not worthy of the name even of "fuel," as it will not support its own combustion.

Than.

(x). Burma.

Tenasserim.—In the Tenasserim Division coal has been found in the Tertiary rocks at a number of localities. Dr. Helfer[6] appears to have been the earliest writer on the subject. In the year 1838 he made his first discoveries and described them in glowing language, which was only exceeded by the terms

[1] *Manual, Geol. Ind.*, III, p. 95.
[2] *Mem., G. S. I.*, Vol. IX, p. 86 (1872).
[3] *Ibid*, Vol. VI, p. 23. (1867).
[4] *Mem., G. S. I.*, Vol. IX, p. 86 (1872).
[5] *Mem., G. S. I.*, Vol. XXI, p. 133 (1884).
[6] *Jour., As. Soc. Beng.*, VII, 701 (1838).

"nexhaustible beds of uniformly good quality" made use of by the Coal Committee.

In 1841 Captain Tremenheere [1] visited and reported on the coal deposits on the Great Tennasserim river at a point 67 miles above Mergui. He described in detail the working of the Government coal prospects at Tendau.

In the year 1855 all the then known localities were either visited by Dr. Oldham [2] or conclusive information was obtained regarding them. Out of 13 named localities, in five,—namely, Bankyop, Tagoo Creek, Banpyai and Manton, on the Great Tennasserim river, and in Tagit Creek on the Little Tennasserim no coal exists,—black carbonaceous deposits incapable of supporting combustion having been mistaken for coal. Out of the remaining eight localities two were too remote to be visited, and the occurrence of coal was doubtful.

In the *Manual of the Geology of India*, Ball [3] quoting Dr. Oldham gives a description of the outcrops at Thoo-hte-Khyoung or Thatay Khyoung, Heinlap or Heinlat, and Kan-ma-pying, all on the Great Tennasserim river; and also at Tsing Koon and Atong-wo, situated respectively on the Little Tennasserim and Lenya rivers. In 1871, Mark Fryar [4] reported favourably on the coal at Tendau, but considered the distance of the deposit from markets to be too great for profitable exploitation.

During the season 1891-92 coal prospecting operations were carried on under the direction of T. W. H. Hughes [5] in Kamapying on the Htiphanko stream, a tributary of the Great Tennasserim river, where a seam of good coal occurs. A year later the whole of the coal outcrops on the Great Tennasserim river were examined by P. N. Bose, and described by him under the name of the Tendau-Kamapying coalfield. The following details are abstracted from his report.[6]

Tendau-Kamapying.—Coal of both Carboniferous and Tertiary ages occurs in the Tennasserim valley. The former is the more widely distributed, but although it has been repeatedly examined

[1] *Cal. Jour. Nat. Hist.*, II, 417-430 (1842).
[2] *Sel. Rec., Govt. Ind.*, X, 31 (1856).
[3] Vol. III, p. 115.
[4] *Geol. papers on Brit. Burma*, 418-419, 440, 444-446 (1871-72).
[5] *Rec., G. S. I.*, XXV, 161 (1892); XXVI, 40 (1893).
[6] *Rec., G. S. I.*, XXVI, 148 (1893).

by means of boring and sinking no workable deposit has been met with. The most promising locality is at Therabwin, but even here the coal is of poor quality and occurs in thin lenticular strings seldom more than 2 or 3 inches in thickness.

The Tertiary coal is found in a narrow synclinal trough, 14 miles in length by 2 miles in breadth, traversed from end to end by the Great Tennasserim river. The dip of the rocks varies from 30° to 35°. Coal is found only on the western side of the river. It was first worked in 1841 at Cha Mitwe (formerly Thatay-Chaung) in the village of Tendau where the thickness is about 7 feet. In this locality the coal seam probably extends along the strike for about 1½ miles. Assuming the average thickness to be only four feet the amount of workable coal within a depth of 300 feet from the surface would be more than half-a-million tons.

About 11 miles further up-stream coal outcrops in Kamapying in the Heinlat stream, and again in the Htiphanko stream three quarters of a mile further north. The maximum thickness of the coal on the Heinlat is 23 feet, but borings and sinkings extending for about 300 feet along the strike proved it to be somewhat irregular. The section exposed by excavation on the Htiphanko was :—

Coal	0′ 10″
Shale	2′ 0″
Coal	2′ 3″
Shale	3′ 0″
Good coal	4′ 6″

Assuming that the Kamapying seam extends for three-quarters of a mile along the strike, with a workable thickness of 15 feet, the amount of coal within a workable depth of 300 feet would be nearly 900,000 tons. The following are analyses of the Kamapying coal :—

	Heinlat stream.	Htiphanko stream (lower bed).
Moisture	16·40	11·34
Volatile matter	35·08	36·40
Fixed carbon	44·24	43·27
Ash	4·28	8·99

The first sample caked poorly and the latter not at all. The coal might be floated down the river to Mergui in shallow draught

barges. Owing to its lignitic character, however, the fuel is not likely ever to command more than a limited local market. Up to the present time no workings on a commercial scale have been undertaken.

Little Tenasserim River—Tsing Koon.—This locality is 121 miles from Mergui and 80 miles from Tenasserim, and is on the frontiers of Siam. The seam or seams examined by Dr. Oldham were too small to be of any practical value; the quality, were it not for the presence of a certain amount of pyrites, is good. The dip is 18°.

Lenya River—A-tong-wo.—This locality is about 8 miles above the Lenya village on the Lenya river, which joins the sea south of Mergui. The coal is exposed in the bank of a small tributary called the Phlia; but it unfortunately proved to be only an irregular bed varying from 1 foot to 2 feet 6 inches in thickness; it is throughout laminar with thin seams of jetty coal between the layers, and very numerous imbedded nodular lumps of a resinous amber-like substance. The whole appearance of the rocks suggested to Dr. Oldham that they were more modern than those of the Tenasserim district. The coal and associated rocks dip at from 35° to 38°, to between 15° and 30° north of east. The coal ignites with some difficulty, but retains its shape after the lumps become red hot. The amber-like resin causes it to blaze up. It comes out of the bed in large solid masses, and if it occurred in abundance would be a useful fuel for many purposes.

Henzada.—Coal in this district was reported on by R. Romanis[1] in 1882, and by M. Stuart[2] in 1910. The best outcrop was found near the Shuayning stream at a point 4 miles west-north-west of Kywaising, a village 15 miles west of the Irrawadi. An excavation exposed the following section dipping at an angle of 30°:—

Coal with four shaly partings	6′ 8″
Carbonaceous shale	1′ 6″
Good coal	2′ 0″
Inferior coal	2′ 0″

Near the village of Hleemouk, 9 miles to the south-west, a seam 22 inches thick occurs. The dip is about 45° and the rocks are much disturbed. A third locality is near Posogyi on the

[1] *Rec., G. S. I.*, XV, 178 (1882).

[2] Report on the Geology of Henzada, Rangoon (1911).

Padau river, 17 miles north of Kywaising. The coal is very friable and varies in thickness from 6 to 18 inches, occasionally pinching out altogether. The general dip is about 60° and the strata are much contorted. The following analyses of the coal have been made :—

	Kywaising seam.[1]		Posogyi seam.
Moisture	1·48	1·55	6·36
Volatile matter	26·58	13·00	18·21
Fixed carbon	65·12	79·90	69·65
Ash	6·82	5·55	5·78

The coal is a bright splintery substance of the nature of anthracite. It is non-coking. To burn it properly a forced draught is required, and very careful firing is necessary. It is excellent smithy fuel. Its main drawback is the small state of division in which it is obtained.

In 1882 the Kywaising outcrops were tested [2] by tunnels and borings made under the supervision of the Local Government, and again in 1908 by a Rangoon Syndicate, but the disturbed condition of the rocks and the transport and labour difficulties have up to the present prevented the exploitation of the deposit on a commercial basis.

Thayetmyo.—Near Thayetmyo coal was discovered [3] in the year 1855, and a mine was opened which at first gave good promise of yielding a quality of coal that would have been most serviceable for the steam navigation of the Irrawadi. Owing to the beds being nearly vertical, mining would have been attended with considerable difficulty. This might not have proved an insurmountable obstacle ; but the fact that the two seams which were originally discovered, gradually merged into one, which ultimately died out, led to the abandonment of operations after a few hundredweights had been extracted. Another seam, also worthless, was discovered, according to Mr. Theobald,[4] near the village of Chouk-kalah on the Mu

[1] Figures furnished by Messrs. Gillanders, Arbuthnot & Co. in 1907.
[2] *Colliery Guardian*, XLVI, 984 (1883).
[3] Oldham, Dr. ; *Sel. Rec. Govt. Ind.*, X, 101 (1856).
[4] *Mem. G. S. I.*, X, pt. 3, p. 154 (1873).

stream, 3 miles south of Tham-bayadeing boundary pillar. It is a bed of carbonaceous shale including one foot of hard coal and a few stringy seams, amounting in all to 18 inches. The dip is 70° to east by north. Its situation is more than 30 miles from the Irrawadi.

In 1878[1] and again in 1885[2] further prospecting was carried on on the deposits near Thayetmyo. Apparently the attempts were quite unsuccessful. In the Shu stream above Sabata, traces of carbonized trunks or lignite have been met with, and have given rise to fallacious hopes of a source of fuel. The rocks in these localities are of eocene age. Similar worthless indications of coal have been found in many localities in Lower Burma, as at Dalhousie near the mouth of the Bassein river.

Arakan Division.—For a period of more than 70 years attention has been directed to the carbonaceous deposits of Arakan. They admit of being discussed in three groups, the northern including the Baronga Islands, the central including Ramri and Cheduba and the southern the mainland in the Sandoway district.

Baronga Islands.—These are three islands situated south of Akyab harbour. On the western coast of the eastern island called Angara-Khyong, about two or three miles from its southern extremity, coal is said to have been found at three localities below high-water mark. In one place it was thought that the bed of coal was 5 feet thick; in another 18 inches; the third being very small. On the central island called Peni-Khyong, at the southern end, coal in a seam one foot thick was reported to exist.[3] The dips are so high and the probability of the existence of a large seam of continuous thickness so slender, that in spite of any results from assays no future can be safely predicted for these deposits, though it is conceivable that a limited amount of useful fuel might be obtained.

Samples from Baronga were forwarded to the Geological Survey by Colonel Sladen, and through the Economic Museum for examination;

[1] *Brit. Burma, Admin. Rep.*, p. 35, 1877-78.
[2] *Rec., G. S. I.*, XVIII, 150 (1885).
[3] *Coal Committee's Final Report,* 1846,

the former proved on examination to be lignite in which the woody structure was apparent. The assays gave the following results :—

Water	4·5	5·0
Volatile, matter	37·5	35·8
Fixed carbon	49·6	52·3
Ash	8·4	6·9
	100	100

It is not known where the exact spots were whence these were obtained, or whether they occurred in real seams or merely in nests, as is not improbable.

A sample of coal forwarded by the Baronga Oil Co. to England for examination by Mr. Redwood, was subjected to destructive distillation and yielded 13·74 per cent. of tar and 12·03 per cent. of ammoniacal liquor. The sample would not coke and it contained 8 per cent. of ash.

Ramri Island.—Although attention has been directed to the carbonaceous deposits of Ramri for many years, only one seam giving even a slight promise of containing coal in workable quantity, has as yet been discovered. Some ten or a dozen localities might be mentioned where at different times hopes were raised that a source of fuel would be found. In the majority of cases these yielded only lenticular nests of lignite, or, in some instances single logs of carbonized wood imbedded in the sandstones ; in the others, as at Hung and near Kyaukphyu, the seams were too thin and too steep to be worked. Under these circumstances it is pleasant to be able to quote from Mr. Mallet's report [1] his account of a seam or rather seams of slightly more promise, but it must be stated that these are unlikely ever to possess any very high commercial value.

The best seams occur less than one mile west-10°-north of the village of Tsetama. One seam has a thickness of 6 feet, and the other, of 2 feet 5 inches. The dip is 50°. The coal is apt to fall to pieces after a short exposure.

Besides the high dip there is one other circumstance unfavourable to the prospect of the six-foot seam ever proving largely productive, and this is that in the upturned edges of the beds with

[1] *Rec., G. S. I.*, XI, 207 (1878).

which it occurs it does not appear except at this one spot, so that its lateral extension is probably limited. Mr. Mallet believed that the cost of raising it would be so high that it would probably not find a market for local purposes at A yab. The following assays are by Mr. Mallet :—

Seam.	Carbon.	Volatile.	Hygrosopic water.	Ash.	Caking properties.	Colour of ash.
Tsetama . .	43·5	28·8	8·4	19·3	Cakes slightly.	Reddish grey.
„ 6-ft. .	38·4	28·9	14·6	18·1	Does not cake.	Light grey.
„ 1-ft. .	48·6	33·1	10·8	7·5	Cakes .	Red.

Cheduba Island.—Mr. Mallet (*loc. cit.*) describes a seam seen in a stream which descends from a hill north-east of Pallang Rao. It is only two feet six inches thick and dips to east-20°-south at an angle of 40°. It is similar in appearance to the coal at Tsetama. A carbonaceous sandstone was described by Captain Halstead[1] as occurring less than a mile from the beach to the south of Pagoda Hill.

Sandoway.—On the mainland of Arakan, in the neighbourhood of Sandoway, thin carbonaceous deposits have from time to time been discovered and samples of lignite from the Arakan Hill Tracts have been forwarded, but at present there are no solid grounds for believing that a deposit of value exists in these regions.

Yenangyaung.—In an account of a visit to the petroleum wells at Rainanhong (Yenangyaung) published in 1797, Captain Hiram Cox[2] mentions that coal is found in the wells at a depth of 130 cubits from the surface. Subsequent writers have referred to the same fact. Its distribution appears to be sporadic, but, it appears to be connected with the occurrence of the oil. From an analysis made in the Geological Survey laboratory the fuel must be a lignite of moderate quality. Similar strings of coal have been met with in the Yenangyat oilfield.[3] None of the occurrences, however, are of any economic importance.

[1] *Jour., As. Soc. Beng.*, X, 444 (1841).
[2] *Asiatic Researches*, VI, 130 (1797).
[3] Grimes, G. E., *Mem., G. S. I.*, XXVIII, 54 (1898).

Pakokku and Myingyan Districts.—In 1873 Captain G. A. Strover [1] mentions that coal is known to exist in the Pakokku district at Yaignaw, east of Nattaik, in the neighbourhood of Yaw. The locality was visited by Mr. P. N. Datta in 1892. No workable deposit was discovered. The analysis [2] of a sample from near Pakhoung village shows that the coal is a lignite of fair quality. Captain Strover also refers to an outcrop of coal near Pagan in the Myingyan district.

Panlaung river, etc.—This coalfield is situated partly in the Meiktila district and partly in the Southern Shan States, at a point about 60 miles south-south-east of Mandalay. Coal in this neighbourhood was mentioned as occurring at Minapalaung by Captain Strover [3] in 1873. The area was examined by E. J. Jones [4] in 1887, who reports that the extent over which coal occurs is from 150 to 200 sq. miles. He examined 11 separate groups of outcrops, the most promising being at Thabyetaungdan, where seams respectively 2 feet and 5½ feet thick were found. The rocks are of Tertiary age, and are much disturbed, lying at angles approximating to the vertical. Owing to this feature and the thinness and extreme inconstancy of the coal seams together with the crushed condition of the coal Mr. Jones was not sanguine of its profitable exploitation. From the following analysis it can be seen that some of the coal is of excellent chemical quality :—

	Average of 3 samples.	Average of 4 samples.
Moisture	2·68	2·76
Volatile matter	21·31	10·63
Fixed carbon	72·39	64·58
Ash	3·62	22·03

A considerable amount of coal is said to have been quarried from these outcrops in King Mindoon's time, for use at the Sagaing iron-works. Coal seams of similar character but inferior quality were also examined by Mr. Jones at Legaung, near Singulebyin and Ngu, near Pwehla, localities some 20 odd miles south-east of the Panlaung coalfield. About 12 miles still further south-east the same observer found a seam of lignite of moderate quality at Thigyit,

[1] *Indian Economist,* V, 14 (1873).
[2] *G. S. I., Laboratory Records.*
[3] *Indian Economist,* V, 14 (1873).
[4] *Rec., G. S. I.,* XX, 177 (1887).

11 miles west of Indeinmyo. The thickness of the bed varies from 2 to 3 feet, and in one case 6 feet The dip is from 15° to 45°. At a later date outcrops of a similar lignite bed were found at Nangon, near Pwehla by C. S. Middlemiss [1] who also examined what he considered to be a continuation of the Panlaung and Legaung coal seams at Payabyu (Po-pyu) near Inwin, 8 miles south-west by south of Thamakan. He also visited the outcrop at Ngotko-Yagyi (Mr. Jones' "Ngu"), and characterised the mineral as graphitic shale. A similar material is said to occur north-east of Thit-e-bin, near Pindaya.

Northern Shan States.—Beds of lignite of late Tertiary age have been found to occur in scattered basins occupying depressions in the ancient Palæozoic floor of the Northern Shan States. Four of these known as the Lashio, Namma, Man-Sang and Man-Se-Le coalfields, have been examined and mapped by officers of the Geological Survey.

Lashio.[2]—The area of this coalfield is about 50 sq. miles and it lies within two or three miles of the terminus of the Mandalay-Lashio railway. Outcrops of coal have been found at several points, but owing to the thick coat of alluvium which obscures the rocks no attempt at correlating the seams and estimating the amount of fuel can be made without recourse to boring operations. The thickest outcrop measures 25 feet, whilst others are 3, $5\frac{1}{2}$, 6 and 11 feet in thickness. Bulk samples of the thick seam were recently obtained from inclines sunk by the Burma Railway Company. After trials the coal was condemned as a locomotive fuel. It is a brown-black lignite, disintegrating on exposure to air. Representative analyses are :—

	Hsunkwe.	Naleng.
Moisture	19·79	17·76
Volatile matter	34·79	35·64
Fixed carbon	30·42	37·40
Ash	13·57	9·20
Sulphur	1·43	..

Namma.[3]—This coalfield lies 11 miles south of the Lashio field, and is of about the same area, *i.e.*, 50 sq. miles. The

[1] *Genl. Rep., G. S. I.*, 1899-1900, p. 150.
[2] Noetling, F. : *Rec., G. S. I.*, XXIV, 2, 99 (1891) ; LaTouche, T. D., and Simpson, R. R. : *Rec., G. S. I.*, XXXIII, 2, 117 (1906).
[3] Simpson, R. R.: *Rec., G. S. I.*, XXXIII, 2, 125 (1906).

principal coal seam is found near Namma village and its outcrop has been traced for about half-a-mile, the thickness varying from 7 to 17 feet. The coal is a lustrous lignite of which the following represents an average analysis :—

Moisture	18·16
Volatile matter	34·96
Fixed carbon	38·39
Ash	7·66
Sulphur	0·83

It has been estimated that about half-a-million tons are available near Namma. A consignment of 7 tons of this fuel was recently experimented with on the Burma Railway, but did not produce a favourable impression on the minds of the officials responsible for the trials. To bring the coal to the railway would necessitate the construction of a branch line 30 miles in length, but neither the quantity nor quality of the fuel is sufficient to warrant the requisite expenditure.

Man-Sang and Man-Se-Le.[1]—Still less important fields occur near Man-Sang and Man-Se-Le, villages, respectively, 16 and 27 miles south and east of the Namma coalfield. The area of each is about 13½ square miles. Outcrops of coal are fairly numerous but none of the seams exceed 4½ feet in thickness. The coal resembles that from the larger areas, and the disabilities which militate against the exploitation of the Namma field are in these cases largely accentuated.

Kabwet, etc. (*Shwebo District*).—The earliest detailed account of coal in this neighbourhood is by T. Oldham[2] who, in 1855, visited three outcrops situated a few miles west of Thingadaw. The first of these lies 1½ miles west of Tembiung. The seam is 4 feet thick and dips at an angle of 15°. The coal is of poor quality but was worked to some small extent for a while.

The second locality is 5 miles further north on the Kibiung stream at a point 5 miles west of Thingadaw. The coal is woody and resinous and has a thickness of 5½ feet including shale bands.

The third locality is 8 miles N.-W. of Thingadaw. The coal is hard and jetty, and contains resinous inclusions. The seam is about 4 feet thick and dips at 8°. A quantity of coal was raised

[1] Simpson, R. R. : *Rec., G. S. I.*, XXXIII, 2, 144 (1906).
[2] *Geol. papers on Burma*, p. 318 (1858).

and used on the Irrawadi steamers. The distance from the Irrawadi is only 7 or 8 miles.

The mines near Kabwet were visited by Dr. Anderson[1] about the year 1870. He mentions workings at Lek-op-bin and Ket-zu-bin, the seam being 6 feet thick and dipping at 35°. The Kabwet coalfield lies between the Kabwet bend of the Irrawadi and the Manchoung, a tributary of that river. There are only one or perhaps two seams, the outcrops of which are found over a considerable area. Most of the coal, however, is of poor quality, and it is only in the locality mentioned above, the Letkobin-Ketzubin area, that a workable seam occurs. The thickness of the coal is about 6 feet and the dip 39°. The following are representative of a large number of analyses of Kabwet coal made in the laboratory of the Geological Survey of India :—

	Letkobin.	Ketzubin.
Moisture	11·94	12·60
Volatile matter	37·68	37·22
Fixed carbon	36·22	41·72
Ash	14·16	8·46

The writer of the first report on an examination of the coalfield is said to have estimated that one and a half million tons of coal were available, but Dr. King,[2] who examined the area in 1894, considered that only from 120,000 to 150,000 tons could be counted upon and strongly advised boring exploration on the east of the Letkobin area. Some three years prior to Dr. King's visit a company opened up extensive mines at Letkobin, and their operations were continued with varying success until 1904 when the workable coal became exhausted. The annual output during the years of the company's operations was from 10,000 to 15,000 tons, the maximum being in 1896 when nearly 23,000 tons were raised.

Upper Chindwin river.—Coal in this neighbourhood was in 1886 reported by Captain Stevens[3] to occur in the Kubo valley, Manipur. A year later an examination of a small portion of the Upper Chindwin coalfields was made by E. J. Jones.[4] This portion he has called the Kalé coalfield. It is situated on the Myit-tha (or Kalé Creek) a few miles above the junction of that river

[1] *Report on the Expedition to Western Yunnan, viâ Bhamo* (1871).
[2] *Rec., G. S. I.*, XXVII, 33-34 (1894).
[3] *Geol. Surv. Ind.* files (1886).
[4] *Rec., G. S. I.*, XX, 171 (1887).

with the Chindwin at Kaléwa. Within an area of about one square mile he found 10 coal seams, only one of which, however, was of sufficient thickness to be workable. This seam is 10 feet thick, of fair quality, but friable. The dip is about 45°. In 1889 a detailed examination of a large portion of the whole area was made by F. Noetling,[1] from whose report the following details are abstracted :—

"The first group of outcrops occupies the Nantahin, Peluswa and Maku valleys, a tract of country 55 miles in length by one mile in breadth, extending from Kalewa in a northerly direction. The second or Telong group runs in a parallel direction, and extends up the Telong valley, the area being about 60 miles in length by 2 miles in breadth."

The coal occurs in beds of various thickness up to 12 feet; but seams of 2 feet and under are the rule. The average dip is at an angle of 45°. The greatest number of continuous seams occurs in the Maku valley, where twenty-five were counted. Taking all circumstances into consideration it was thought that a thickness in different seams of at least 24 feet of coal is available wherever the whole series of the Chindwin coal measures is developed. More precise information was obtained of the Nantahin-Peluswa area, which has a length of 25 square miles over which ground a total thickness of 48 feet of coal are considered to be available. It was calculated that down to an inclined depth of 1,000 feet from the outcrop there are 210 million tons of workable coal within this limited area.

The coal is of hard texture, particularly in the thicker seams; and in the 10-feet seam near Kaléwa there are none of the partings of clay which depreciate the value of many of the other seams. Disregarding two samples yielding, respectively, $15\frac{1}{2}$ and 22 per cent. of ash, the following is the average analysis of 13 different samples of the fuel :—

Moisture	10·14
Volatile matter	34·59
Fixed carbon	49·95
Ash	5·30

Except for some small quarries near Kaléwa which were at work for a short time in 1886, no mining has been done on these

[1] *The Upper Chindwin Coalfields*, (flscap., Govt. Press, Rangoon, 1893).

deposits. Although their proximity to the Chindwin river affords a possible line of communication, yet they will probably remain undeveloped until such time as the westward extension of the Burma Railway system brings them into touch with down-country markets.

Pinlebu.—Coal of miocene age is known to occur on the Mu river near Pinlebu, a village in the Katha district situated 25 miles north-west of Wuntho. The deposits were examined by F. Noetling[1] in 1893. Coal outcrops were discovered in several localities, the most promising being on the Moungaw stream, near Yuyinbyet, south of Pinlebu, where a seam from 4 to 5 feet thick dips at an angle of 10°. The following is the analysis of a sample of this coal :—

Moisture	6·6
Volatile matter	34·2
Fixed carbon	52·2
Ash	7·0

Most of the other outcrops are either too thin or of too poor quality to be workable. The nearest outcrop is 32 miles over rough broken country, from the railway at Wuntho. The building, however, of the proposed connecting link between the Burma Railways at Wuntho and the Indian Railway system at Lumding, on the Assam Bengal Railway, might possibly lead to the development of these coal deposits.

Bhamo District.—That coal occurred in this district was known to Captain Strover[2] in 1873. The locality was Shwegu, a town on the Irrawadi below Bhamo. What is probably a continuation of the same deposits was visited by H. H. Hayden[3] in 1896. The place is Mithwe, a village about 5 miles south-east of Lagat. The coal occurs in thin seams, the best of which is 2 feet 8 inches thick, but only extends for 112 feet along the outcrop; it is shaly and poor, and the beds are highly disturbed, and penetrated by igneous intrusions.

On the authority of F. Noetling[4] and C. L. Griesbach we have it that coal exists near Mogaung. Neither of these observers appears, however, to have visited the deposits. The former states that

[1] *Rec., G. S. I.*, XXVII, 120 (1894).
[2] *Indian Economist*, V, 14 (1873).
[3] *Rec., G. S. I.*, XXX, 6 (1897).
[4] *Rec., G. S. I.*, XXV, 133 (1892).

coal seams outcrop on the Saungka, a stream joining the Mogaung stream 16 miles above Mogaung, and from the general geology of the neighbourhood he opined that the coal strata are of Tertiary age, of limited extent, and much disturbed. Griesbach [1] mentions that small quantities of lignite are brought into Myitkyina by the natives for sale. From enquiries which he made the mineral is said to come from the neighbourhood of Talang, north of the Pungin Kha, about 16 miles N. N. W. of the confluence of the two streams which unite to form the Irrawadi river. The seam is said to be from 2 to 3 feet in thickness.

(xi). Central India.

The earliest mention of coal discoveries in these territories is in 1829, when Captain Franklin [2] found outcrops of good coal at a point situated near the junction of the Tipan stream with the Son river. This place is on the southern margin of what is now known as the Sohagpur coalfield. In 1845, on the authority of the Coal Committee,[3] coal was said to exist near Sohagpur and also on the Keyverji and Johilla rivers and near Cheirdiah. In Bundelkhand also Franklin [4] reported the occurrence of coal, but H. B. Medlicott [5] in 1860 found that the deposit was black shale, only very slightly carbonaceous, occurring in the Vindhyans, rocks infinitely older than any known coal deposits. Little, however, was known of the coal resources of Central India until 1881, when the examination of the area was taken up by the Geological Survey of India. T. W. H. Hughes was in charge of the investigation, and in 1885 the Department published his memoir [6] on "The Southern Coalfields of the Rewah-Gondwana Basin," in which a detailed account is given of the Umaria, Korar, Johilla, Sohagpur, Kurasia, Koreagarh and Jhilmilli coalfields. Descriptions of the three last-mentioned fields are included under the Central Provinces Section.

Umaria.—This, the smallest of the rich coalfields of the Rewah-Gondwana basin, is situated on the Umrar river, a tributary of the Mahanadi, and is 36 miles from Katni on the East Indian Railway.

[1] *Rec., G. S. I.,* XXV, 129 (1892).
[2] *Gleanings in Science,* II, 217 (1829).
[3] *Coal Committee's Final Report* (1846).
[4] *Op. cit.*
[5] *Mem., G. S. I.,* II, 91 (1860).
[6] *Mem., G. S. I.,* XXI, pt. 3 (1885).

The Bilaspur-Katni branch of the Bengal-Nagpur Railway passes through the centre of the field. The exposed area of the coal-measures (Barakars) covers about 6 square miles, but to the north they dip under younger deposits, and are probably continuous with those in the Korar coalfield, 12 miles distant. There are 6 coal seams, four of which are being worked. Their thickness is as follows :—

No. I seam	4′ 6″ to 5′ 0″.
„ II „	4′ 6″ to 7′ 8″.
„ III „	8′ 6″ to 12′ 4″.
„ IV „	3′ to 4′ 6″.

The dip of the measures is slight—about 4° to N. E.—and the deepest mine-shaft is only 270 feet in depth. The coal is non-coking and some of it is of good quality as can be seen from the following analysis made by Mr. T. W. H. Hughes [1] in 1884 :—

Moisture	5·46
Volatile matter	19·71
Fixed carbon	66·71
Ash	8·12

From the reports of the railway companies using the coal, it appears that the coal now being placed on the market is very much inferior to fuel with the above analysis.

Washing was resorted to some years ago, but abandoned on account of the excessive waste of coal involved. In 1885 Mr. Hughes estimated that there were 55 million tons of coal available within a depth of 500 feet from the surface. In 1896 and 1902, the total quantity of workable coal actually proved by shafts and borings was estimated by Mr. R. J. W. Oates, [2] the manager of the colliery, to be 24 million tons.

The development of the Umaria coalfield was commenced in 1882 under the direction of T. W. H. Hughes of the Geological Survey of India, to whom is chiefly due the credit of the discovery of these valuable coalfields. From 1883, when 1,290 tons were raised, the output steadily rose, and in 1903 191,686 tons of coal were mined. In 1910 the output was 130,400 tons. In 1900, the

[1] *Mem., G. S. I.*, Vol. XXI, Art. 3, (1885).
[2] *Annual Reports of the Rewah State Collieries.*

Government of India, who, up to that time, had worked the collieries on royalty, handed them over to the Rewah Durbar, under whose direction they are now being carried on with much profit to the State.

Korar.[1]—This coalfield is 9½ miles square and lies some 3 miles north of the Umaria area. Few outcrops of importance have been discovered, but a bore-hole put down to a depth of 63 feet between Kotalwar and Korar proved coal seams, respectively, 8, 4, 4, and 7 feet thick. The dip is about 9° and a sample of weathered coal from the outcrop of one of the seams mentioned above yielded the following analysis :—

Moisture	5·04
Volatile matter	12·56
Fixed carbon	65·48
Ash	16·92

Johilla.—Coal on the Johilla river was known to occur as early as 1840, when Dr. Spilsbury[2] mentions the fact. The measures are exposed about 13 miles S. E. of Umaria and constitute two tracts, of which only the larger, an area of 11½ square miles, is known to contain workable coal deposits. The most notable outcrop is near the confluence of the Ganjra stream with the Johilla river, where shallow borings proved seams of coal, respectively, 17 and 6 feet in thickness. The inclination of the rocks is moderate and the quality of the coal good. The following is the average of three analyses given by Hughes :—

	Marjada outcrops.
Volatile matter	34·85
Fixed carbon	54·43
Ash	10·72

In summing up the capabilities of the field Mr. Hughes[3] says "There appears to be quite 20 feet of coal and although the outcrop of the seam cannot be traced for more than two miles, it is

[1] *Hughes, op. cit.*
[2] *Jour. As. Soc. Beng.*, IX, 903 (1840).
[3] *Op. cit.*

almost a certainty that both in the direction of Khodargaon and of Pali shallow sinkings would touch it." Although unwilling to hazard a close estimate he considered that within a depth of 500 feet there are at least one hundred million tons of coal available.

In 1902 borings undertaken on behalf of the Rewah Durbar, met with encouraging results and the field is now looked upon as a valuable reserve against the exhaustion of the Umaria coalfield at some far distant period.

Sohagpur.—This, the main area of coal measures exposed in south Rewah, has a superficial extent of nearly 1,600 square miles and stretches from the river Son to the river Rer. The number of coal seams is small, and for such an area there is not an abundance of coal. The following are the most promising outcrops found by Hughes :[1]—

A coal seam exceeding 5 feet in thickness comes to the surface between Bargaon and Kelhauri and can be picked up along its outcrop for a distance of 10 miles, appearing thrice in the Son river. Subsequent exploration by G. F. Reader[2] in 1899-1900, showed that this seam varies in thickness from 15½ feet (containing 13½ feet of good coal) on the Bageha stream near Amlei to 4 feet 8 inches on the Son river near Bokahi. The dip is about 3°. On the Jamuniha stream near Nandnah, seams respectively 5 and 4½ feet thick outcrop and can be traced over a very large area. At Bhalmuri and Dumarkachar outcrops a seam of coal exceeding 7 feet in thickness, but including a twelve inch band of carbonaceous shale. This seam can be traced in the bed of a stream for a mile and a half and its continuation is met with in other streams further afield. In a stream north of Balbahara a 10-feet seam of coal outcrops and its probable extension is found in streams to the westward.

Of the seams examined by Reader workable thicknesses with fair qualities of coal were found to occur south of Sabo in a tributary of the Bageha stream, near Rampur in a tributary of the Katna stream, as well as in the Amlei-Bokahi area mentioned above.

[1] *Op. cit.*
[2] *Genl. Rep., G. S. I.*, 1899-1900, p. 69.

The following are a few of the published analyses of coal samples from this field :—

	Amlei.	Bokahi.	Nandnah.	Bhalmuri-Dumarka-char Seam.	Balbahara.
Moisture . .	5·2	Nominal.	. .	6·7	. .
Volatile matter .	22·2	27·4	25·20	28·2	29·04
Fixed carbon .	57·2	61·0	62·69	59·6	54·08
Ash . . .	15·4	11·6	12·11	5·5	16·88

Although the number of coal seams within the field is not large, yet the lateral extent is so great and the strata are, as a rule, lying at such low angles, that a very large amount of coal is available at a minimum depth.

Singrauli.—The name of this coalfield is derived from that of a petty principality now absorbed in the Rewah State and the adjoining districts of the United Provinces. The first discovery was made in 1840 by Captain Wroughton[1] and analyses of the coal gave only 2 per cent. of ash. The best-known locality was Kota, where four bands of coal aggregating 4 feet 9 inches in thickness are found in a total thickness of 6 feet 3 inches of strata. For some years mining was carried on, the coal being carried over bad roads, a distance of about 80 miles to Mirzapur, where it was sold for use on the Ganges steamers.

In reporting on the coalfield in 1857, D. Smith[2] refers to an outcrop of 9 feet of clean coal at Toorah, near Nowar Nagar, about 6 miles west of Kota. He also found coal being quarried in Rewah at Pudree, about 18 miles west of Kota, the seam being 21 feet in thickness.

In 1894-96 the area was geologically mapped by a party under R. D. Oldham[3] during the course of the season's operations in Rewah. The total area of Damudas is about 900 square miles. Coal seams were found in several localities, the thickest being near Ujeini and Amilia where thicknesses of 6 and 5½ feet, respectively,

1 *Eng. Jour.*, Calcutta, II, 340 (1859).
2 *Sel. Rec. Govt. Ind.*, LXIV, 93 (1868).
3 *Rec., G. S. I.*, Vol. XXVIII, 117 (1895).

were encountered. The analyses[1] of samples brought to Calcutta appear to have been disappointing.

In 1896 mining was again carried on in the Mirzapur District (United Provinces). About 1,000 tons of coal were raised, but the enterprise was soon abandoned.

(xii). Central Provinces.

Ramkola-Tatapani.—This area is situated in the Sarguja State. It comprises the north-eastern portion of an extensive spread of Gondwana rocks, which reaches into Central India on the west. It is bounded on the east and west by the rivers Kunhar and Rer, and covers about 800 square miles.

Less than one-third of the area is occupied by Lower Gondwana rocks; the remainder being covered up by newer deposits. It is much disturbed and cut up by faults and there are numerous sheets and dykes of trap.

The coal-bearing rocks (Barakars) cover about 100 square miles. They contain a fair number of coal-seams, but few of them are of workable thickness or quality. The best seam is found in the vicinity of the Morne river; it varies from $3\frac{1}{2}$ to 17 feet in thickness, and can be traced for more than a mile.

The area was examined and described by C. L. Griesbach[2] in 1878-9, but he did not hazard an estimate of the available quantity of fuel nor submit the latter to the test of analysis. Owing to the uncertainty on these points and the isolated position of the field its present economic importance is not great.

Jhilmilli.[3]—This coalfield is situated in the Jhilmilli State, and lies across the Rer valley on the south-west of the Ramkola-Tatapani field.

The coal measures (Barakars) occupy a lenticular area of about 41 square miles and their boundary is faulted on the north. In the Manikmara stream seven coal outcrops are exposed, the respective thicknesses of which are—1′0″, 2″0″, 3′6″, 1′4″, 1′2″, 6′ 6″, and 6′0″. Only the top of the sixteen-inch seam was exposed

[1] *Rec., G. S. I.*, XXX, 4 (1897).
[2] *Mem., G. S. I.*, Vol. XV, p. 129 (1880).
[3] Hughes : *Mem., G. S. I.*, Vol. XXI, p. 69 (1885).

and from the analysis of this portion appended it can be seen that it is of excellent quality :—

Volatile matter	33·8
Fixed carbon	60·6
Ash	5·6

It is, moreover, a good coking coal.

All these seams are nearly horizontal and accordingly so far favourable for working. Their position in the valley is, however, eminently not so.

Bisrampur.—This field lies in Central Sarguja, at an elevation of 1,800 feet above sea-level; its area is about 400 square miles. The coal measures are Barakars; they are little disturbed by faulting and are for the most part horizontal. Trap intrusions are few. A large number of coal seams has been discovered; most of them are of small thickness and the covering of alluvium which obscures the rocks renders their correlation impossible.

Ball,[1] who mapped the area in 1872, considered that good coal exists in fair abundance; but that borings are necessary before the extent and thickness of the seams can be estimated. The landlocked and isolated position of the field renders it unlikely that its resources will be drawn upon for many years to come.

The following analyses of the coal are taken from Mr. Ball's report :—

	Average of 2 samples from the Rer and Pasang rivers.	Average of 3 samples from the Mahan and Masan rivers.
Volatile matter	37·6	32·3
Fixed carbon	57·0	48·1
Ash	5·4	19·6

Bansar.—A small coalfield in this locality was mapped by Lala Hira Lal [2] in 1888-89. It lies some 5 miles east of Bisrampur and has an area of about 10 square miles. A coal seam exceeding one foot in thickness was found at a point 1 mile N. W. of Darridih.

Lakhanpur.—This field is situated on the Hestho river partly in Sarguja and partly in Bilaspur. It is separated from the

[1] *Rec., G. S. I.*, Vol. VI, p. 25 (1873).
[2] *MS. Report*, 1888-89.

Bisrampur area by a fault and a belt of Talchirs. In 1882 Ball[1] wrote concerning the field as follows :—

"The coal-bearing rocks are Barakars, and they contain several seams of coal. The best seam outcrops in the Chandnai river near Kutkona; it is 5 feet 6 inches thick and contains about equal parts of good, fair and burnable shaly coal."

He suggested borings within a mile radius of Ambera and Kutkona, and considered that there was a good prospect of coal being found of fair quantity and quality at no great depth and in aproximately horizontal beds.

In 1885-87 the whole field was examined by Lala Hira Lal,[2] who estimated the total area to be 340 square miles. He mentions outcrops of coal seams as occurring on the Mani stream near its confluence with the Rer river, near Salih, near Rode, on the Ranai stream near Khorbahar, near Kohikundra, on the Atem stream north of Parsa, on the Chornai stream, on the Bisrar stream N. and N. E. of Kedai and in other localities. The thickness of coal varies from 3 to 9 feet, whilst the ash varies from 5 to 28 per cent. A typical sample from a seam exceeding 5 feet 6 inches in thickness on the Atem stream, north of Parsa gave on analysis :—

Moisture	7·50
Volatile matter	28·70
Fixed carbon	50·90
Ash	12·90

None of the samples possessed caking qualities.

Panchbhaini.—In Paharbula, Sarguja. This is a small area of about 4½ square miles. According to Lala Hira Lal[3] there are several seams of good quality, varying from 18 to 40 inches in thickness.

Sendurgar.[4]—This outlier of the Lakhanpur coalfield is situated in Mahtin, and lies some 5 miles west of the Hestho river. The coal measures form a plateau of about 20 square miles in

[1] *Rec., G. S. I.*, Vol. XV, p. 108 (1882).
[2] *MS. Report*, 1885-87.
[3] *MS. Report*, 1885-86.
[4] Lala Hira Lal: *MS. Report*, 1885-86.

extent. The following are analyses of coal seams with a thickness of 10 and 4 feet, respectively :—

	10′ seam.	4′ seam.
Moisture	6·50	8·46
Volatile matter	20·20	30·74
Fixed carbon	50·20	54·40
Ash	23·10	6·40
	non-coking	caking.

The country is a rough one and difficult of access.

Damhamunda.[1]—Another outlier is found near Damhamunda in the same sub-division. The area is $4\frac{1}{2}$ sq. miles. The coal is poor and the seams thin.

Rampur (*Sarguja*).—This coalfield must not be confounded with that portion of the Raigarh-Hingir field which Mr. G. F. Reader has described in the *Memoirs of the Geological Survey of India,* Volume XXXII, part 2, and to which he gave the same name.

The area under discussion adjoins the Lakhanpur coalfield on the north, and is bounded on the east by Mainpat; on the south it passes into the Mand area described below, and on the west it is connected with the great area of coal-measure rocks which stretches to Korba.

In 1882[2] Ball reported that the only seam of any value which has been discovered crops out near the foot of Ramgarh hill. It is 4 feet 6 inches thick and the coal is rather stony. Coal is also said to occur on the Chornai river.

The field was re-visited in 1886-87 by Lala Hira Lal[3] who estimated the total area to be 70 square miles. He mentions numerous localities in which coal occurs in seams of from 2 to 7 feet in thickness. From his analyses the inorganic matter appears to vary from 12 to 25 per cent., but a five feet seam outcropping in a tributary of the Dhamgora stream at a point a mile east of Bhakue, yielded less than 4 per cent.

Kurasia.—This field is situated on the east of the Hestho river in the Korea State. The superficial area of the Barakar rocks is 48 square miles.

In the course of a partial examination of the field Hughes[4] discovered seven outcrops of coal. The three most important seams

[1] Lala Hira Lal : *MS. Report,* 1885-86.
[2] V. Ball : *Rec., G. S. I.,* Vol. XV, p. 111 (1882).
[3] *MS. Report,* 1886-87.
[4] *Mem., G. S. I.,* Vol. XXI, p. 203 (1885)

occur in the neighbourhood of the village of Kurasia; their respective thicknesses are $13\frac{1}{2}$, $6\frac{1}{2}$ and 8 feet. From the following analyses it can be seen that the coal is of excellent quality :—

	$13\frac{1}{2}$ feet seam.	$6\frac{1}{2}$ feet seam.
Moisture	2·20	6·84
Volatile matter	26·95	25·59
Fixed carbon	64·65	59·95
Ash	6·20	7·62

Although no estimate of the total quantity has been put forward there is little doubt that in this field there is a large and valuable reserve of fuel. As, however, it lies fully 30 miles distant, over difficult country, from the nearest railway line (Bengal-Nagpur Railway, Katni-Bilaspur branch) its resources are not likely to be requisitioned for some time to come.

Koreagarh.—This independent area of Barakars is a small basin of which merely the outline has been traced. It lies rather more than 2 miles to the south-east of the Kurasia field and covers about 6 square miles.

No seams of any value have been noticed, but Hughes [1] considered it highly probable that with closer search they will be proved.

The Chhattisgarh coalfields.—These fields are situated in the Chhattisgarh Division and the neighbouring tributary states on the north. The area comprises some 2,500 square miles, but is connected on the north-west with the Sarguja fields. Over a large portion of the ground the coal-measures are overlain by younger rocks. The former are exposed in three distinct areas:—(1) in the neighbourhood of Korba, (2) on the Mand river, (3) in the vicinity of Rampur on the Eeb river.

Korba.—This portion of the Chhattisgarh coalfields stretches through the village of Korba in an east and west direction for some 36 miles with an average width of about 8 miles, but also extends far to the north being practically continuous with the Lakhanpur coalfield. It was first visited by W. T. Blanford,[2] in 1870, who reported favourably on the thick seam outcropping in the Hasdu river near Korba. In 1886 boring exploration was undertaken under the superintendence of W. King,[3] who found

[1] *Mem., G. S. I.*, Vol. XXI, p. 204 (1885).
[2] *Rec., G. S. I.*, Vol. III, 54-57 (1870).
[3] *Rec., G. S. I.*, Vol. XIX, 223 (1886), XX, 198 (1887).

that the Korba seam had a thickness of 69 feet and consisted of a series of alternations of poor coal and carbonaceous shale, yielding on the average 37·28 per cent. of ash. A more promising seam, about 5 feet in thickness, occurs near Ghordewa. Assays of this seam gave the following figures :—

	Outcrop.	Boring 72 feet deep at 429 feet from outcrop.
Moisture	8·52	5·30
Volatile matter	30·03	28·08
Fixed carbon	54·65	53·21
Ash	6·80	13·41

On the Ganjar stream, 22 miles west of Korba, a seam 22 feet thick outcrops. The average analysis of the coal yielded 25 per cent. of inorganic material. As the coalfield lies not less than 20 miles from the railway, and no large amount of good coal has been proved it does not offer much inducement to investors.

Mand river.—This coalfield was partially examined by Blanford [1] in 1870, and in more detail by Ball [2] in the following year. Although neither was successful in finding workable coal seams of good quality they were hopeful that boring operations would be successful in bringing them to light. The length of the coalfield from north to south is about 35 miles and it lies along the valley of the Mand river, the width being about 10 miles on the average. There is a large number of coal seams, but their quality is inferior, most of them being little if any better than carbonaceous shale. In 1886, a number of bore-holes were put down by King [3] in the neighbourhood of Tuinidih, about 20 miles N. W. of Raigarh. In every case the quality of the coal seams was found to be too poor for profitable exploitation.

Rampur.—This, the most eastern portion of the Chhattisgarh coal area, extends from the Eeb river for a distance of more than 50 miles to the north-west reaching within 8 miles of the Mand river field. The coal-bearing rocks are exposed over an irregular area of about 300 square miles. They were originally described by Ball [4] as the Raigarh-Hingir coalfield, but the present name was

[1] *Rec., G. S. I.*, III, 71 (1870).
[2] *Rec., G. S. I.*, XV, 112 (1882).
[3] *Rec., G. S. I.*, XIX, 222 (1886); XX, 194 (1887).
[4] *Rec., G. S. I.*, IV, 101 (1871); *ibid*, VIII, 102 (1875).

adopted by the Government of the Central Provinces for convenience, the most important part of the area being in the neighbourhood of Rampur,[1] a village situated 24 miles north of Sambalpur. Between the years 1884 and 1886 systematic boring experiments were carried on by King[2] in the Lillari, Oira and Baisandar valleys, but although there is a large number of seams of considerable thickness the quality of the coal was in every case found to be inferior. Some 10 years later interest in the field was again aroused by the discovery of a seam of coal in the excavation of the foundation of the Eeb bridge on the Bengal-Nagpur Railway. A number of bore-holes, one of which reached a depth of 828 feet, and a shaft were put down in the neighbourhood by the railway company, but the general results were unsatisfactory, the extension of the seam remaining unproved. In 1900 a detailed examination of the Eeb river was made by G. F. Reader,[3] who demonstrated that the seam found in the bridge excavations is faulted. He considered this to be the only seam of value within the area and advised the putting down of a series of shallow borings on the outcrop duplicated by the fault. The thickness of this seam in the best section obtained is 7 feet 10 inches, including a band of bituminous shale 8 inches thick. Samples of this seam obtained from shallow pits gave the following analyses :—

Moisture	8·00	9·00
Volatile matter	20·90	24·30
Fixed carbon	52·20	54·90
Ash	18·90	11·80

In concluding his account of the Eeb river coal area Mr. Reader gave it as his opinion that despite the extensive boring experiments which had been carried out the lower 200 feet of the Barakar rocks were still unexplored. He advised the putting down of a bore-hole to the Talchirs at a point ⅜ mile E. S. E. of Kodopali, and estimated that the depth would be about 600 feet. Such a boring would pass through the Eeb river seam and facilitate the determination of its faulted outcrop.

1 Rampur was recently included in the Bengal Presidency, but a portion of the coalfield is still in the Central Provinces.

2 *Rec.*, XVII, 123 (1884); XVIII, 169 (1885); XIX, 210 (1886); XX, 200 (1887).

3 *Mem., G. S. I.*, Vol. XXXII, 89 (1901).

In 1909 the area again attracted attention and the establishment of a working colliery was initiated. In 1910, 830 tons of coal were mined.

Lameta Ghat, etc.—This locality is on the right bank of the Narbada, near Lameta, and about 9 miles W. S. W. of Jabalpur. The coal is of Upper Gondwana age; it occurs as a seam 2 feet 11 inches thick, of which an 8-inch layer is composed of shale in two bands.[1] The fuel is impure and has a distinctly lignitic character; a picked sample yielded 20 per cent. of inorganic matter. Coal, on approximately the same geological horizon was found at a depth of 70 feet in a well at Jabalpur. The Lameta coal has been quarried intermittently for brick-burning purposes since early times. Coal of the same age was also extracted on the Sher and Machariwa rivers near Sehora and similar deposits have been examined in the following localities: [2]—

(1) On the Mahanadi, N. E. of Jabalpur;
(2) In the Hard river, a tributary of the Sakkur;
(3) On the flanks of Nimugarh, south of Mohpani.

In no single case have the deposits been considered worthy of exploitation for more than purely local purposes.

Wardha Valley.—These coalfields are situated in the Chanda and Wun districts. They occupy the valley of the Wardha river for a distance of about 72 miles in a straight line, the total area being 1,600 square miles.

The coal-bearing rocks (Barakars) have a thickness of only 250 feet, and as a consequence their distribution is very broken, and the area they occupy at the surface small. There is hardly a connected exposure in the field, and the knowledge which has been acquired of the composition of the rocks, and their order of succession is due far more to the details ascertained by borings than to any natural sections. There appears to be only one coal horizon, and it occurs near the top of the coal measures. The thickness of coal varies from nothing up to 90 feet, the average being about 30 feet. The general dip of the rocks is low.

Our knowledge of the coalfields is almost entirely due to the labours of T. W. H. Hughes,[3] who between 1870-1876 mapped

[1] Mallet: *Rec., G. S. I.*, XXII, 146 (1889).
[2] Medlicott, H. B.: *Rec., G. S. I.*, III, 65 (1870).
[3] *Mem., G. S. I.*, XIII, pt. 1 (1877).

the area, and superintended the execution of an elaborate scheme of boring operations.

Warora.—The Warora basin is situated about 62 miles south of Nagpur and in the Chanda district. The coal-bearing rocks are overlain by younger deposits, chiefly alluvium. Borings commenced in 1870 proved that they occur in a basin to the east of Warora at a depth of from 63 to 285 feet from the surface. The area actually proved was about three-quarters of a square mile, but the extension of the basin to the south appeared to be probable. There are two seams of coal, the thicknesses [1] of which average 12 and 15 feet, respectively. The coal is somewhat friable and disintegrates on exposure to the air. It is inferior in quality to Raniganj coal, owing to the excess of moisture and smaller amount of fixed carbon which it contains. The following analyses were made prior to 1877 : [2]—

	Average of 2 samples.	Average of 2 samples.
Moisture	11·72	?
Volatile matter	29·33	33·25
Fixed carbon	43·80	52·50
Sulphur	1·55	?
Ash	13·60	14·25

The coal is very liable to spontaneous combustion, and about 70 per cent. of the proved coal-bearing area is said [3] to have been lost by fire and to be dammed off.

The quantity of coal in 1877, was estimated by Hughes to be 20 million tons, and he considered that the probable extension of the basin to the south might swell this amount to 60 or 100 million tons.

Collieries were worked in this field under the direction of the Government of India from 1873 to 1906, and owing to the excessive quantity of water and the frequency of underground fires, considerable expense was incurred. In 1891-93, efforts were made to prove by means of borings the extension of the coal seams to the dip, but they appear to have been unsuccessful.

In 1906 so considerable a subsidence took place as to necessitate the closing down of the collieries. Such a contingency had been

[1] R. W. Clarke: Coal Mining in India, *Trans. Inst. Min. Eng.*, Vol. XXII, p. 87 (1901-02).
[2] Hughes : *loc. cit.*, pp. 99-100.
[3] Clarke : *loc. cit.*

provided for by the sinking of shafts at Ballarpur, about 30 miles further down the Wardha river. The staff and machinery were transferred to these new winnings and a considerable output is now being obtained.

Since the commencement of mining operations at Warora up to the year 1904-05 nearly 3 million tons of coal[1] were raised; the output for 1904-05 was 112,319 tons, whilst the largest output on record was raised in 1902, the amount being 153,336 tons.

Ghugus.—This area contains about 3 square miles. Allowing a thickness of 30 feet, the amount of coal would be 90 million tons. The average assay of 32 boring samples of the coal gave :—

Volatile matter	33·49
Carbon	45·61
Ash	20·90

A pit was sunk in 1870. The depth to coal was 74 feet and the thickness of the seam exceeded 32 feet. For some time about 70 tons of coal per month was raised, but the mine was eventually closed down owing to the advantage of position possessed by the Warora basin.

Wun.—In this area there are at least 80 square miles of probably productive coal lands, the total amount of coal being about 2,100 million tons. Actual proof of the occurrence of coal was obtained throughout 13 miles of country between Wun and Papur; the area is 7 square miles and allowing 15 feet of coal, the amount would be 105 million tons.

Similar proof exists of an area 5 square miles between Junara and Chicholi, under which the thickness of coal averages 30 feet. The quantity is 150 million tons. In the above figures only the coal above a depth of 500 feet is taken into account.

In the early days of the exploration shafts were sunk in the Wun-Papur area at Pisgaon; the seam was found to be 21 feet thick, and to be of the usual quality. Analyses are as follow :—

	10th to 12th feet.	Lower 4 feet.
Volatile matter	19·6	19·2
Fixed carbon	62·8	65·1
Ash	17·6	15·7

[1] *Annual Report on the Warora Colliery*, 1904-05.

Ballarpur, Sasti and Paoni.—This coal area lies 7 miles S. S. E. of Chanda and is situated chiefly on the Hyderabad side of the river. At an early date borings proved coal in two local basins, one between Paoni and Gaori and the other east of Sasti. The average thickness is 40 feet, which, over an area of 1½ square miles, gives 60 million tons of coal. Analyses of the coal are :—

	Average of 2 outcrop samples of the lower 7½ feet and.	Average of 5 samples from A shaft.
Moisture	4·50	22·76
Volatile matter	36·20	
Fixed carbon	50·55	60·95
Ash	8·75	16·29

In 1905 an exploration for coal was carried on by the Government of the Central Provinces at Ballarpur on the British side of the river. Borings proved 36 million tons of workable coal over an area of 2 square miles. Two pits reached the seam, which exceeds 50 feet (20 feet workable) in thickness, at a depth of 200 feet from the surface. A working colliery has since been established and in 1910 the output was 93,276 tons. Up till July 1910 some 200,000 tons of coal had been raised from this mine. An analysis of a sample from the boring cores gave the following result :—

Moisture	11·10
Volatile matter	31·56
Fixed carbon	45·47
Ash	11·87

Bandar.[1]—This field is situated near the village of Chimur, 30 miles north-east of Warora, in the Chanda District. The existence of coal measures under a small tract of Kamthi beds, five to six miles square, has been proved by boring. Three seams of coal have been ascertained to exist, and these have a maximum total thickness of 38 feet. The coal is similar in character to that of Warora.

[1] Hughes: *Mem., G. S. I.*, XIII, 145 (1877).

Fig. 1. DRAWING WATER AT SINKING PIT,
JELGORA COLLIERY, JHARIA,

R. R. Simpson, Photo. *G. S. I., Calcutta.*

Fig. 2. HEADGEAR AND SCREENING PLANT,
BALLARPUR COLLIERY, CENTRAL PROVINCES.

Satpura Basin.[1]—The Satpura Basin, so called from a range of hills included within it, is situated south of the Narbada valley. It is difficult to speak of this area as a single expanse of coal measures, since, as a matter of fact, they only appear at intervals under the margins of younger groups, covering a wide extent of country which stretches for a distance of about 170 miles. Accordingly, the estimated dimensions of the basin vary much according to different authorities. About 2,000 square miles appears to be a safe minimum, but besides this it should be remembered that there is a considerable tract in which the underlying formations are concealed by the Deccan trap, and a large area towards Jabalpur, in which no coal measures have been proved to exist under the younger formations which prevail there.

The principal localities where coal measures occur are near Mohpani and in the valleys of the Tawa (Shahpur or Betul field) and Pench (Chhindwara field) rivers. Under the orders of the Chief Commissioner of the Central Provinces, advised by the Geological Survey, borings[2] have been made both in the alluvium of the Narbada valley on the margin of the rocky area and in valleys to the south of it within the area occupied by the younger rocks but, though these borings were carried to considerable depths, the coal measures were not reached; these depths were, Gadawara, 251 feet; and Sukakheri, 491 feet. Neither of these when stopped had proved the rocks underlying the recent alluvial deposits. In the Dudhi valley borings, at Manegaon to the depth of 420 feet and at Khapa to the depth of nearly 720 feet, established the fact that the younger formations still persisted, the coal measures, if they exist below, not having been reached. As the progress of boring by hand at 720 feet was slow and costly the work was abandoned.

Borings at Tundni, 10 miles west of the Mohpani field, which it was hoped might prove a similar area of coal measures on the margin of the basin, were unsuccessful. Two of them at depths of 328 and 172 feet, respectively, struck contact and trappean rocks, and another further south, at 243 feet, had to be abandoned owing to the tools sticking, and as the dip of the beds was high there was no inducement to renew the attempt.

[1] J. G. Medlicott: *Mem., G. S. I.*, II, pp. 97, 268 (1860); H. B. Medlicott: *idem*, X, p. 133 (1873); *Rec., G. S. I.*, III, p. 63 (1870) and VIII, p. 65 (1875).

[2] *Annual Report, G. S. I.*, 1877; *Rec., G. S. I.*, XI, p. 7 (1878).

Near Lokartalai on the Moran, at the western extremity of the basin, where some carbonaceous outcrops occur, borings were put down to depths of 254, 84 and 88 feet, but without proving coal. In the open valley of the Tawa on the south of the basin at Kesla, on the Betul and Hoshangabad road, borings to the depth of 302 and 241 feet had the same result as the boring at Khapa.

Other borings between the Piparia and Bunkheri stations, on the Great Indian Peninsula Railway, and Pachmari, although sunk in deposits belonging to the Upper Gondwanas, close to Talchir outcrops, failed to reach the coal measures, which are there consequently overlapped.

Mohpani.[1]—The Mohpani coalfield is the most northerly of the several small coalfields of the Satpura-Gondwana basin, and for many years it was the only one of them which had been extensively worked. It is situated in the Narsinghpur district of the Central Provinces, and lies on the south of the Narbada alluvial valley, at the foot of the northern spurs of the Satpura hill ranges. The exposed coal-measures (Barakars) occupy an area of rather more than one square mile. Their limits are ill-defined. On the south, they pass under younger rocks, and on the east and west they are overlapped by the same deposits. The northern limits of the field are obscured by the Narbada alluvium. There are four seams of coal with average thicknesses of 17, 25, 5 and 6½ feet respectively. The average analysis of a number of samples of the coal recently assayed in the laboratory of the Geological Survey of India, is :—

	Coal.	Splint.
Moisture	2·52	2·84
Volatile matter	24·26	20·55
Fixed carbon	48·71	37·42
Sulphur	0·50	0·95
Ash	24·01	38·24

The coal has only occasionally a caking quality.

A recent estimate has fixed the amount of workable fuel at rather more than 8 million tons, but further exploration may considerably augment this total.

[1] J. G. Medlicott: *Mem., G. S. I.*, II, pt. 2 (1860). H. B. Medlicott: *Mem., G. S. I.*, X, 133, (1873); *Rec., G. S. I.*, III, 62, (1870); IV, 66 (1871); V, 109 (1872); VIII, 65 (1875); XII, 95 (1879); *Unpublished Notes, G. S. I.*

Mining operations were undertaken by the Nerbudda Coal and Iron Company in 1862 and the Company worked on under exceptional difficulties until 1904 when the collieries were sold to the Great Indian Peninsula Railway Company. Prior to 1892 their workings were confined to a small area of about 30 acres on the Sitariva river. Great trouble was experienced owing to the extreme irregularity of deposition of the coal-seams, the considerable disturbance which they have undergone, the large flow of water and the occurrence of underground fires. Since 1875, large sums of money have been expended both by the Government of India and by the Company, in unsuccessful attempts to prove coal by means of borings outside this area. In 1892, however, the pertinacity of the manager, Mr. F. L. G. Simpson, who was assisted by Dr. King and Mr. LaTouche of the Geological Survey of India, was rewarded by the discovery of a second coal-bearing area of more than 100 acres in extent, situated about 2 miles west of the old mines. Further borings have, since, considerably extended the boundaries of this ground. The present workings are entirely confined to this area, the old mines having been finally closed down in 1902.

The output for 1910 was 39,484 tons.

Shapur (*Betul*).—This field is situated on the Tawa river in the neighbourhood of Shapur, a village in the Betul district. The exposed coal-bearing rocks have an extent of about 26 square miles. They are divided by faults into three distinct portions to which the following names have been given :—

(1) The Dolari area.
(2) The Machna river area.
(3) The Suki and Sonada area.

Outcrops in the neighbourhood of Sonada attracted much attention in 1848 when a quantity of coal was extracted and conveyed to Bombay for steamer trials.[1] In 1875 the coalfield was geologically mapped by H. B. Medlicott,[2] who mentions a number of fairly promising outcrops, but apparently found no coal seam of value. Under his advice, in 1881, a number of borings [3] were put down within the field. All of these went completely through

[1] *Sel. Rec. Bom. Govt.*, XIV, 27-115 (1848).
[2] *Rec., G. S. I.*, VIII, 65 (1875).
[3] *Rec., G. S. I.*, XVI, 2 (1883).

the coal measures, but in none of the holes was a workable coal seam encountered.

Chhindwara.—The exposed area of coal measures in Chhindwara covers an area of about 100 square miles and stretches from within a few miles of the Shapur field, in an easterly direction for 50 miles to a point 10 miles nearly due north of the civil station of Chhindwara. They occupy a portion of the valleys of the Tawa, Pench and Kanhan rivers.

Since the discovery of the fields in 1852 by Dr. Jerdon [1] and Lieutenant Sankey, a large number of reports have been made, the most important being by Blanford [2] in 1866 and E. J. Jones [3] in 1887. The latter distinguished five semi-detached areas of coal measures, which he named the Sirgora, Barkoi, Hingladevi, Kanhan and Tawa fields, respectively.

The Sirgora area covers rather more than a square mile. The best coal seam found is from 4 to 5 feet thick and has been proved over about $\frac{1}{8}$th of a square mile, but its outcrop probably extends for $1\frac{1}{2}$ miles.

The most promising outcrops are found in the Barkui (Pench Valley) area which has an extent of about $7\frac{1}{2}$ square miles. The principal coal seam is known as the Barkui seam. It is 6 feet thick and of good quality. It was worked for some time many years ago, but owing to difficulties of transport the works were eventually abandoned. A second seam $3\frac{1}{2}$ feet thick outcrops between the villages of Bhandaria and Dongur-Parasia; whilst a third, $15\frac{1}{2}$ feet thick and containing 12 feet 3 inches of coal is found between Chinda and Dighawani. Another promising seam, 5 feet thick, outcrops about $\frac{3}{4}$ mile N. W. of Gajundoh.

In the Hingladevi area which occupies nearly 3 square miles the only outcrop of importance occurs in the Hingladevi stream near the deserted village of Dhow. It is said to be about 5 feet thick.

The Kanhan area covers 12 square miles. Seams respectively exceeding 10 and 8 feet in thickness occur near the villages of Datla and Panara.

In the Tawa area, notwithstanding the fact that the measures occupy an extent of some 79 square miles, outcrops of coal are few.

[1] *Quar. Jour. Geol. Soc.*, X, 55 (1852)
[2] *Rec., G. S. I.*, XV, 121 (1882).
[3] *Mem., G. S. I.*, XXIV, pt. 1 (1887).

The most important seam outcrops near Tanse and is 5 feet thick. Another seam, 11 feet thick, is found near Patakhera, but is faulted close to its outcrop and has not been traced to a distance.

The following analyses of samples of Chhindwara coal have been published :—

	Barkui field. (Average of 3 samples.)	Kanhan field. (Average of 3 samples from Panara and Datla.)	Kanhan field. (Datla.)	Tawa field. (Average of 2 samples.)	Sirgora field.
Moisture . .	22·8	3·05	5·34	3·05	28
Volatile matter .		19·08	28·36	26·20	
Fixed carbon .	53·5	31·82	48·58	51·90	61·6
Ash . . .	23·6	46·05	17·72	18·85	10·4

Extensive prospecting operations were carried on in 1904 chiefly in the Barkui (Pench Valley) area, by private firms. The results were so encouraging that in 1907 the Bengal Nagpur Railway Company's lines were extended to the field. At the present time the Great Indian Peninsula Railway Company is engaged in building a line from Itarsi to the coalfield. This should be opened in 1913.

Since 1905 collieries have been actively worked at Chandameta and Barkui, and an output of 87,677 tons of coal was raised in 1910. A number of other mines were opened in 1908, but are now closed down until such time as the extension of the Great Indian Peninsula Railway Company's line into the field enlarges the supply market.

(xiii). Hyderabad.

Within the limits of the Nizam's territory coal-bearing Barakar rocks are found in the following localities, proceeding from south to north : Kunnigiri, Madavaram or Damercherla, Lingalla, Singareni, Alapalli, Kamaram, Bundella, Chinur (or Sandrapali), Tandur, Aksapur, Antargaon and Sasti.

These localities, with the exception of Alapalli, are all situated on or beyond the margins of a tract of Kamthi rocks, which doubtless overlie coal measures, but to what extent is not yet known.

It can only be determined by deep borings. Dr. King's memoir[1] on the geology of the Pranhita-Godavari valley contains the latest information on the subject.

Kunnigiri or Kanigheri.—This is a small tract of Barakar rocks, which extends for a distance of about 6 miles at the salient angle of the Lower Godavari basin, 25 miles south-west by west of Bhadrachellam. No coal has yet been found, but the presence of the coal-measure rocks is of great importance with reference to future exploration by boring.

Madavaram or Damercherla.—This small field is situated in the bed of the Godavari below Bhadrachellam, extending thence for a short distance on either side into British and the Nizam's territory, respectively. It was first reported upon by Dr. W. T. Blanford[2] in 1871, by whom it was estimated that on the British side, as above stated, there are 25,000 tons of coal, of which perhaps only half are available on account of the great admixture of shale. Under the orders of His Grace the Duke of Buckingham a shaft was sunk to a depth of 56 feet in 1880; but the work was not completed.

In the bed of the river on the Nizam's side a series of 14 borings was suggested by Dr. Blanford, but after six had been carried out operations ceased in consequence of representations made by the Nizam's Government. In 1874, according to Dr. King,[3] some borings were made by the Nizam's officers in an area 3 miles from the village of Ryagoodium, and 5 miles south of the Godavari. Three seams of coal were discovered as follows: (1) One foot thick at 247 feet from surface; (2) four feet thick at 272 feet; (3) six feet thick at 314 feet. The quality of the coal appears to have been somewhat inferior.

The following statement concerning later developments on the British side of the river was furnished by the Collector of the district in 1897:—"The extent of coal-bearing rocks on the British side is about 16 square miles, of which about 10 square miles may be taken as containing workable coal. A seam of fine quality has been found opposite the village of Rajahzompalli, and over 2,000 tons were taken out of the trial pit. It averages 5 feet 6 inches in thickness. This seam is estimated to yield, after deducting $\frac{1}{3}$ for waste, about 24 million tons of coal." According to the official

[1] *Mem., G. S. I.*, Vol. XVIII, pt. 3, (1881).
[2] *Rec., G. S. I.*, Vol. IV, p. 59, (1871).
[3] *Op. cit.*

statistical returns of output 3,657 tons of coal were raised from the Rajahzompalli pits between the years 1891-95. In the latter year, however, the enterprise was abandoned.

Lingalla.—In the small area of Barakar rocks surrounding Lingalla, two seams, neither of them exceeding 2 feet in thickness, were found by Dr. Blanford[1] in the bank of the Godavari, and another 5 feet thick in its bed. A boring put down to test the extension of this bed inland was unsuccessful.

In the year 1880, officers in the Nizam's service were engaged, according to Dr. King,[2] in making borings to test the field on the western side of the river, but they were apparently unsuccessful in proving coal seams of workable thickness and quality. As the coal found on the British side is of poor quality, and as it would be difficult to work these beds under the bed of the river, even if they were of better quality, the field is not of much value.

In 1897 enquiries made by the Geological Survey elicited from the Collector of the district the following statement: "The coal-bearing rocks on the British side cover about 5 square miles. A seam of coal was struck in 1891, and a trial pit, 11 feet deep, sunk. Seventy tons of very good coal were taken out. The coal was 5 feet thick (including a bed of shale 6 inches thick, 2 feet from the floor). Allowing $\frac{1}{3}$ loss on mining, this field on the British side is estimated to yield 8 million tons of saleable coal."

Singareni.—The Singareni coalfield is situated near Yellandu, about 115 miles due east of Secunderabad. It is an elongated strip of Lower Gondwana rocks, $13\frac{1}{2}$ miles in length, $3\frac{1}{2}$ miles in greatest breadth, and with a total area of about 19 square miles. The coal-measures (Barakars) occupy about 9 square miles, but except in a few small patches they are completely covered up and overlapped by unconformable deposits of Kamthi age. The average dip of the rocks is from 8° to 10°. Except on the north the boundaries of the field are faulted against the crystalline rocks on which the basin lies. Four seams of coal have been found. Their respective thicknesses are as follow :—

	Feet.
Thick coal, *alternating bands of coal and shale* . .	30 to 40
New coal contains 20 per cent. of inorganic matter .	$6\frac{1}{2}$
Stone coal ,, 30 ,, ,, ,, .	$4\frac{1}{2}$
King seam	$3\frac{3}{4}$ to 7

[1] *Rec., G. S. I.*, Vol. IV, p. 59.
[2] *Mem., G. S. I.*, Vol. XVIII, p. 194, (1881).

The lowest or King seam is the only one being worked, but part of the thick coal seam is considered to be workable. The following analyses have been published :—

	Thick coal.	King seam.
Moisture	?	7·60
Volatile matter	34·50	25·25
Fixed carbon	52·50	56·50
Ash	13·00	10·65

The coal from the King seam is a dull, hard, non-coking steam-coal, considered to be about 15 per cent. inferior to the best Bengal coal. It contains little pyrites, but is liable to oxidation, causing it to split up and take fire spontaneously on exposure to the air.

The coalfield was discovered [1] and described by Dr. King, who found the only known outcrop of coal within the area. Borings were subsequently put down, and in 1886 the working of the coal was commenced under the direction of T. W. H. Hughes. In 1887, Mr. Hughes [2] reported that 156 million tons was a moderate estimate of the amount of coal in the thick coal and King seam., whilst Dr. Saise [3] in 1894 considered that there was a total quantity of 45 million tons within the King seam alone. The mines are owned by the Hyderabad (Deccan) Company, who hold a monopoly of the coal and minerals over an extensive tract of country. In the earlier stages of development 75 per cent. of the coal was extracted, small pillars being considered sufficient for the support of the strong sandstones overlying the seam. A wide-spread subsidence which occurred in 1903, seriously curtailing the output of coal, has proved the unsoundness of the judgment then exercised. Up till 1894 the coal was brought to the surface through inclines driven down from the outcrop, but since that time shafts have been largely employed; the deepest was sunk in 1904 and is 750 feet in depth. The mechanical equipment of the collieries is of modern description and includes coal-picking belts, compressed air and electrical pumping and hauling plant, and ventilating fans. The surface and pit bottoms are lighted by electricity and communication by telephone is provided. By the construction of a dam in 1898 a large water supply was assured, the quantity previously available being precarious.

[1] King: *Rec., G. S. I.*, Vol. V, pt. 2, p. 65, (1872).
[2] Hughes: *Report to the Director, Hyderabad (Deccan) Co.*
[3] *Rec., G. S. I.*, Vol. XXVII, p. 53, (1894).

Fig. 1. No. 7 INCLINE, SINGARENI COLLIERIES. HYDERABAD.

R. R. Simpson, Photo. *G. S. I., Calcutta.*

Fig. 2. HEADGEAR AND SCREENING PLANT. SINGARENI COLLIERIES. HYDERABAD.

The output of the colliery is consumed by the principal railways and mills in Southern India, and owing to the favourable geographical situation of the mines the company holds a practical monopoly over an extensive area. In 1903 the outturn was 362,733 tons, a reduction of more than 20 per cent. on the figures for the previous year. This curtailment was entirely due to the subsidence referred to above. In 1910, 506,173 tons of coal were produced.

Alapalli.—Dr. Blanford [1] describes the discovery of fragments of coal in the Kinarswami stream, a tributary of the Godavari, near a village called Alapalli, 30 miles south-west of Dumagudam. The rocks seen there seemed to be Barakars, but no seam was found, though a concealed outcrop may exist under the sand.

Kamaram.[2]—This name has been given to two small fields situated near the village of Kamaram, which lies 40 miles a little north of east from Warangul. The larger one is 6 miles long by about 1 mile broad; it consists of Talchir, Barakar and Kamthi rocks lying at high angles. It includes two seams of fair coal measuring, respectively, 9 feet and 6 feet. The available coal is estimated at 1,132,560 tons, and it is stated to be equal to the average coal of the Wardha fields. Its position is unfavourable to its development as it is off the main lines of communication. The smaller field, which is about half a square mile in area, is believed to be of no importance.

Chinur.—A narrow outcrop of Barakar coal measures between the village of Chinur and Sandrapali was discovered by Mr. Hughes.[3] The total thickness of the beds is 200 feet; no outcrop of coal is disclosed, but large fragments of coal which had been carried into the Godavari by the Sandrapali stream were found. Mr. Hughes was of opinion that a boring on the right bank of the Godavari below the point where the stream joins it would strike coal at no great depth. He alludes to the old operations in connection with the supposed occurrence of coal at Kota,[4] 4 miles north of the Godavari.

[1] *Rec., G. S. I.*, Vol. IV, p. 82, (1871).

[2] King, W.: *Rec., G.S.I.*, Vol. V, p. 50 (1872); and *Mem., G. S. I.*, Vol. XVIII, pt. 3.

[3] *Rec., G. S. I.*, Vol. XI, p. 22, (1878).

[4] Walker, Dr.: *Madras Jour. of Lit. and Sci.*, Vol. XVII, p. 261, (1856); and Vol. XVIII, p. 256, (1857).

Tandur.—As being about the centre of a strip of Barakar rocks which extends from Kairgura to Aksapali, the village of Tandur may be used to indicate the position. It contains one seam of 15 feet, most of which is coal and much of that of fair quality. Mr. Hughes (l. c.) traced this seam with varying thickness as far as the Guloti river, where the dip is 11° to north-20°-east. To test its further extension southwards borings are recommended.

Aksapur.—Between Kasni and Aksapur there is a small exposure of Barakars, but no coal is yet known to exist.

Antargaon.—South of Antargaon the Barakar rocks, according to Mr. Hughes, include a seam of about 6 feet, of which 9 inches is shale. The following analyses are from this locality and from the above-mentioned Kairgura seam :—

	Kairgura.	Antargaon.
Fixed carbon	45·6	51·26
Volatile matter	42·2	28·25
Ash	12·2	20·49
	100	100
Moisture	9·4	8·7

Mr. Hughes states that the Antargaon samples were from the surface ; they may, therefore, perhaps not give a fair indication of the quality of the coal. Both coals include a large proportion of moisture, which is a common characteristic of the coal in these fields.

Sasti.—The coal of Sasti and Paoni is referred to in the account of the Wardha valley field, although it is in Hyderabad territory. One seam of 50 feet has been proved. It contains a considerable proportion of good coal from which fair results were obtained in a trial at Bombay. Mr. Hughes estimates the area to be $1\frac{1}{2}$ square miles. Mining operations were carried on here by the Nizam's officers from 1871 to 1874.

(xiv). Jammu and Kashmir.

Coal has been long known to exist in the Jammu hills. The Dandli outcrop was visited by H. B. Medlicott [1] in 1859 and the same observer in 1876 published a report [2] on the general geological features of the country. Detailed reports on the economic

[1] *Official Correspondence on Coal and Iron in the Punjab*, (1859).
[2] *Rec., G. S. I.*, Vol. IX, 49, (1876)

value of the coal deposits were made by LaTouche [1] in 1888, R. R. Simpson [2] in 1904 and C. M. P. Wright [3] in 1906. The coal-bearing rocks are of Tertiary (subathu) age; they are much disturbed and, as a rule, lie at high angles. Denuding agencies have exposed them in at least six separate areas situated in the hills some 30 miles north of the city of Jammu. Owing chiefly to the difficulty of transport no one of the fields is at present worthy of commercial exploitation. The seams have been much crushed and the coal has acquired a graphitic texture, and is extremely friable. It is very variable in composition, and, as a rule, the volatile content is low, and the ash percentage high.

Ladda-Sangar Marg.—In this the main area the length of the outcrop is about 40 miles. The single coal seam varies from nothing to 20 feet in thickness. The only workable portion lies between Ladda and the Anji valley, where the seam averages about 31 inches in thickness and $1\frac{3}{4}$ million tons of coal are considered available whilst about 2 million tons in addition are possibly workable.

Siro Valley.—This coalfield lies about 8 miles west of the principal field. The coal is of fair quality and occurs in two seams from one to four feet thick. The dip of the rocks is at an easy angle. It has been estimated that more than $\frac{3}{4}$ million tons could be extracted from within a mile of the outcrop.

Lodhra, Mehowgala, Kalakot and Dandli.—These are detached fields of which the first lies 10 miles north-east and the others from 6 to 40 miles to the south-west of the principal coalfield. The quality of the coal in the Mehowgala and Kalakot fields is fair, but the difficulties of extraction too great for profitable exploitation. In the Lodhra and Dandli fields the fuel is worthless.

Ans river.[4]—On the Upper Ans river, a tributary joining the Chenab near Riasi, thin strings of bright brittle coal are common in rocks considered by Lydekker to be of Carboniferous age.

Jehlam river.[5]—At Kohala and Uri on the Jehlam river, and in other localities among the rocks of Tertiary age in Kashmir thin strings of coal are not infrequent. Nearly 30 years ago about a bushel was extracted near Kohala and forwarded to the

[1] *Rec., G.S.I.*, Vol. XXI, 62, (1888).
[2] *Mem., G.S.I.*, Vol. XXXII, pt. 4, (1904).
[3] *Rec., G. S.I.*, Vol. XXXIV, pt. 1, pp. 37-39, (1906).
[4] Lydekker, R. : *Mem., G.S.I.*, Vol. XXII, 332, (1883).
[5] *Ibid.*

Commissioner of Hazara. The occurrences are of no economic importance.

(xv). Madras and Southern India.

To the great importance which an accessible supply of good coal would possess in Madras is no doubt to be attributed the number of discoveries in that part of India of so-called coal seams, which on investigation by qualified experts have in most cases proved to be something very different from what the enthusiasm of the discoverers led them to believe. These discoveries, which were calculated to, and did, stimulate the interest of the Government and of the public, gave rise to a large amount of literature, whether in the form of original descriptions with the speculations dependent thereon, or of subsequent correspondence. As this literature still exists it is right that it should be noticed here. The statements made in one volume must be placed side by side with their refutation in others. If this were not done the former might be a cause of trouble and confusion in the future when all memory of the refutation had passed away. As a rule the extravagant speculations of enthusiasts find a more ready circulation than do the more matter-of-fact and often less sanguine opinions of experts.

As evidence of the thoroughness with which search has been made in the Madras Presidency the following are not without their value. It would surprise and amuse the reader were a list made of all the heterogeneous substances whose presence has been stated to afford "favourable indications" of the presence of coal.

Malabar and Travancore.—A carbonaceous deposit, which was discovered at several points along the Malabar Coast by Captain Newbold [1] and General Cullen,[2] having given rise to a supposition that coal might be found close by, may be most conveniently described here.

The first exposure of this bed described by Captain Newbold was seen in the bank of the Bepur river within the range of the tide. It was a lenticular mass varying in thickness from 5 feet down to 2 inches. Portions were laminated and earthy; others seemed to consist wholly of carbonized woody matter; the colour varied from greenish to jet black. In places shells were imbedded. The further description mentions carbonized trunks and branches

[1] *Madras Jour. of Lit. and Sci.*, Vol. XI., p. 239.
[2] *Op. et vol. cit.*, p. 242.

eroded and projecting from the mass. Similar deposits were met with at Vorkully (Warkilly), 15 miles south of Quilon, in the banks of the Tutalla river, in South Malabar and between Palghat and Calicut. The bed at Quilon, which had a lenticular shape, was stated by General Cullen to be included in laterite which rests on gneiss. This locality was subsequently examined by Dr. King,[1] who found that the lignite occurs with Tertiary sandstones and alum shales, which he thought are probably of the same age as the Cuddalore sandstones. There appears to be no prospect of these deposits yielding a large amount of fuel.

Mysore.—Dr. Hunter,[2] Superintendent of the School of Art, Madras, described as coal a substance received from Dr. Orr of Bangalore, which he said was from shaly stuff, and which burnt feebly, emitting a bituminous smell, but did not catch fire; it was in thin layers not more than from half an inch to three-fourths of an inch thick. It was coloured green with chlorite, and the fact of its being in very small pieces and associated with what is called a "true transition conglomerate," very rich both in iron and manganese, was apparently considered to be a good "indication." This coal does not appear to have attracted so much notice as some of the other "discoveries" noted below.

Pondicherry.—In 1883 a discovery of "lignite" was made in French territory, under the alluvial flat between Pondicherry and Cuddalore. An account of the occurrence was published by Dr. King in the *Records of the Geological Survey*[3] but no officer of the Department appears to have examined the deposit. Borings were put down at Bavur (Bahour), Aranganur (2 miles north-north-east of Bavur) and Koniakovil (5 miles north-east by north ot Bavur), and a seam of carbonaceous material varying from 27 to 50 feet in thickness proved at depths of from 203 to 330 feet. The average assay of seven samples analysed in Paris gave 8·35 per cent. of ash and 91·65 per cent. of volatile matter. On the strength of these flattering results a company was formed with the object of mining the deposits and compressing the fuel into briquettes. Nothing, however, was done and although, according to A. P. de Closet,[4] the hitch was purely a financial one, the inference

[1] *Rec., G. S. I.*, Vol. XV, 87-102, (1882).
[2] *Indian Economist*, II, p. 210.
[3] *Rec., G. S. I.*, Vol. XVII, 194, (1884).
[4] *Indian Engineering*, IX, 290, (1891).

is that the quality of the "lignite" was found to be not up to the standard of the first analyses. Samples furnished, by the engineer of the company, to the Geological Survey of India were found to consist of a brownish-black, crumbling, slightly sandy, carbonaceous mud. Analyses in the Survey laboratory and also by the Chemical Examiner for Bengal gave—

—	A Lignite. (Average of two analyses.)	A Lignite.	A Briquette.	B Briquette. (Average of two analyses.)	B Lignite.
Moisture	19·38	35·3	17·4	9·44	16·28
Volatile matter . . .	25·28	29·1	25·6	32·30	38·55
Fixed carbon	27·95	25·2	23·0	26·25	37·72
Ash	27·39	10·4	34·0	32·01	7·45

Place's Garden, Chingleput.—In 1891 the débris from a boring for artesian water at Place's Garden, Kilacheri, Chingleput, was examined by R. B. Foote,[1] who, from the indications therefrom, was of the opinion that the boring, which commenced at the surface in rocks belonging to the upper division of the Gondwana system, had penetrated beds representing the Damudas. The locality is within 30 miles of Madras. At that time the boring had reached a depth of 307 feet, had passed through 25 feet of bituminous shale, and was stopped owing to lack of funds. By the help of subsidies granted by Government boring has been resumed at recurring intervals. Early in 1905 the depth attained was 660 feet, and so far no coal seams have been passed through.

Arkonam.—The cores from a series of borings near Arkonam in North Arcot were examined by Mr. H. Walker of the Geological Survey of India in 1911. The greatest depth attained was 991 feet. Mr. Walker considered that the rocks passed through belong entirely to the Upper Gondwana system. No workable coal is known to occur in rocks from this system.

Bellary.—Near Gooty samples of coal were discovered by Dr. Hunter in 1871, and the Madras Government were strongly urged to have borings made in order to win the seam from which they

A. By the Geological Survey of India.
B. By the Chemical Examiner, Bengal.
[1] *Rec., G. S. I.*, Vol. XXV, 2, (1892).

were supposed to have come. Before this was done, Mr. Foote [1] was deputed to examine the actual spot where the coal had been picked up. He found that the prevailing rock was granitic gneiss traversed by trap, and he demonstrated most clearly that the coal must have either dropped off a passing cart or have been carried by some other means from a depôt of English coal on the railway, 3 miles off.

Nellore.—Mr. G. Powell [2] in 1857 discovered in four different spots in the Caligherry taluk a substance which he states has such a strong similitude to coal that he "takes the liberty of calling it coal," and the places where he obtained it in quantities "seams"; notwithstanding his matter-of-fact account of its mode of occurrence, his samples proved, on examination by Mr. Wall, to be simply fragments of schorl,[3] but they did include one combustible substance which Mr. Wall stated to be asphalt, but it appeared to have no history. Some real coal, that had previously been found here by Mr. Powell, Mr. Wall concluded had been carried there by accident. A piece of lignite from the alluvium in the Tada taluk had been shown to Mr. Wall by Dr. Hunter.

Kadapah.—Dr. Hunter in the year 1871 brought to the notice of the Madras Government the opinion of a Mr. Adams, a practical coal-miner, that there were good indications of coal at a spot 5 miles north-north-west of Kadapah, where the limestones of the Karnul series have been quarried. The locality was visited by Mr. Foote,[4] who failed to find the faintest trace of any carbonaceous matter in the rocks.

Kistna District.—In the year 1851 Colonel Applegarth was impressed with the idea that the rocks of Jugiapetta contained coal, and having made several small sinkings a substance which supported combustion was brought to him by those whom he employed; much correspondence ensued, and at last, in January 1868, the locality was visited by Dr. Oldham, who was accompanied by Colonel Applegarth and Mr. Sturt, Acting Head Assistant of the district, who had already endeavoured without success to find traces justifying a belief in the existence of a coalfield.

After careful examination, Dr. Oldham was compelled to report [5] that there were no grounds whatever for hope that coal would

[1] *Rec., G. S. I.*, Vol. IV, p. 16.
[2] *Madras Jour. of Lit. & Sci.*, Vol. XVIII, p. 291.
[3] *Cf.* King, W. *Rec., G. S. I.*, Vol. VII, p. 160.
[4] *Rec., G. S. I.*, Vol. VI, p. 17.
[5] *Proceedings, Madras Govt., Rev. Dept.*, 5th March 1868.

be found in the area. The rocks, without exception, belonged to formations long anterior to the coal-bearing rocks of India, and their lithological and metamorphosed characters were wholly inconsistent with the idea of coal occurring with them. There was, moreover, no more reason for coal occurring there than in any other part of the districts where the same rocks are found.

The Government of Madras accepted with regret the fact that Dr. Oldham's exploration and report had proved "beyond all doubt" the non-existence of coal in the valley of the Kistna.

But the matter was not allowed to drop. Colonel Applegarth again and again addressed the Government on the subject, and published letters in English and Indian newspapers, insisting upon the existence of a coalfield where the subsequently published geological report by Messrs. King[1] and Foote[2] showed it absolutely impossible that coal measures should ever have been found. At length, in the year 1874, on the suggestion of Mr. H. B. Medlicott, then Officiating Superintendent of the Geological Survey of India, the Government of India addressed a letter to the Government of Madras proposing that Mr. Vanstavern, then engaged on borings in the Beddadanol field, should be directed to set the matter finally at rest by making borings at points indicated by Colonel Applegarth with his own hand on his own map.

In April 1875 Mr. Vanstavern supplied sections showing the rocks passed through in eleven borings at the indicated localities at Raveralu and Vadadey. These borings, it is perhaps almost needless to remark, did not prove the presence of any rocks younger than those seen at the surface nor did they encounter any rock resembling coal. Phœnix-like, this matter will possibly rise under the fostering care of some enthusiast who may meet with the early positive statements. It is for this reason alone that so much space has been devoted to the subject here.

Godavari Valley.—Although there is an extensive tract of Kamthi rocks which may overlie coal measures in the Godavari valley, there are only a few points on its margins where they actually crop out, and as yet it is not known how far they may extend underneath, nor at what depths the coal would be found if deep borings

[1] *Mem., G. S. I.*, Vol. VIII, (1872).
[2] Special *Memorandum* on the subject by Mr. Foote, *Dept. of Agriculture, Revenue and Commerce,* 1874.

were undertaken. The outcrops in the Madras Presidency are at Beddadanol and Madavaram (or Damercherla).

Beddadanol.—This field, which is about $5\frac{1}{4}$ square miles in extent, is situated about 38 miles west-north-west of Rajamahendri. It was first discovered by Dr. W. T. Blanford[1] in 1871. Subsequently in 1875 it was visited by Dr. King,[2] who gives further details as to the strata which are exposed. No coal was seen, but the sandstones presented a strong resemblance to those of the Singareni field. Borings made here by Mr. Vanstavern in 1874 fully bore out the prediction that this was an area of coal measures, as four seams were struck, the largest being $4\frac{1}{2}$ feet thick and at a depth of 188 feet 4 inches from the surface. But the quality of the coal, as indicated by analyses made by Mr. Tween, showed that it was excessively poor stuff and perfectly worthless as fuel. This is a most unfortunate fact, as the discovery was the first genuine one which had been made in the Madras Presidency.

The analyses were as follows :—

	Average.		Picked.	
	Coal.	Coke.	Coal.	Coke.
Carbon	16·4	22·5	37·0	59·5
Volatile	30·6	..	37·8	..
Ash	53·0	77·5	25·2	40·5
	100·0	100·0	100·0	100·0

In the *Manual of the Geology of India*, Vol. III, Ball quoting King's opinion states that "It seems to be still possible, however, that borings to the deep within the margin of the overlying Kamthi rocks may prove coal of better quality and greater thickness. The coal proved, it should be remembered, was in all probability near the original edge of the deposit, where it might easily be less pure and less thick than nearer to the centre of the basin."

In 1903 exploration was taken up once more; this time by a private firm. A number of boreholes were put down, but the

[1] *Rec., G. S. I.*, IV, 49-52 and 59-66, (1871).
[2] *Idem*, V, 112, and VII, 159, (1872-74).

undertaking was abandoned before the holes had been carried to a depth sufficient to demonstrate that coal seams are non-existent.

Damercherla (*or Madavaram*).—The most important part of this field being included on the Nizam's side of the river Godavari, it is described under the Hyderabad section. The amount of coal on the British side was considered by Dr. Blanford not to exceed 25,000 tons.

(xvi). North-West Frontier Province.

No coal of economic value has as yet been discovered in this province. As early as 1833 Lieutenant Burnes [1] wrote a short account of what was supposed to be coal from the neighbourhood of Kohat, where it was found near the petroleum wells. The substance contained 37 per cent. of volatile matter and only 6·2 per cent. of fixed carbon; it was apparently a bituminous shale. In 1838 the same individual forwarded to Mr. Prinsep [2] for analysis a specimen of lignite of fine quality said to have come from a thin seam near Luagarkheyl, a village under the Malik Buda, between Tak (Tank) and Kaneegorum (Kaniguram).

In his report on the Kohat Salt District, written in 1876, A. B. Wynne [3] mentions a supposed find of coal near Dand, north-west of Shakardarra. Further enquiry from the local officials disclosed a doubt as to whether the locality were not Shin Dand, a village near the Jawai (or Zhuwakai) Pass, between the Kohat and Peshawar districts. Nothing further was heard of the discovery, which may be referred either to the thin layer of lignite occurring in Upper Tertiary sandstones in other parts of the country, or to the nummulitic horizon. In his account of the geology of the Sherani hills, T. D. LaTouche [4] alludes to previous reports of coal discoveries in that country, and while admitting that coaly strings occur in rocks of nummulitic age, states that he did not discover or hear of any actual seams.

(xvii). Punjab.

The coal of the Punjab has for many years attracted notice, the great importance which a supply of good fuel would possess,

[1] *Jour. As. Soc. Beng.*, II, 267, (1833).
[2] *Jour. As. Soc. Beng.*, VII, 853, (1838).
[3] *Mem., G. S. I.*, Vol. XI, 294, (1875).
[4] *Rec., G. S. I.*, Vol. XXVI, 96, (1893).

if found in the vicinity of the Indus, having caused attention to be directed to every spot where any trace of carbonaceous matter had been seen on the surface.

The earliest writer on the subject appears to have been J. Prinsep, [1] who in 1838 reported on specimens of coal collected in the Salt Range and elsewhere by Lieutenant (afterwards Sir Alexander) Burnes. Since that date a copious literature has accumulated. Reference to the individual papers will be found in the appendix.

The whole of the known deposits of importance are of Tertiary (eocene) age, and are found chiefly in the Salt Range, but also occur in the hills north of the Rawalpindi plateau. The following is a list of the localities visited by Oldham [2] in 1864 :—Bhaganwala, Kheura, Pidh, Dandot, Nila, Kuruli, Nurpur, Sowakhan, Dehiwal, Kutta, Chamil, Sunglewan, Amb or Umb, Kalabagh, Kotki, Chushmea and Mulla Khel. All of these places are situated in the Salt Range; Bhaganwala is the only locality in which Dr. Oldham considered that any large amount of coal might be profitably extracted at that time.

Bhaganwala.—Near the eastern end of the Punjab Salt Range, about 19 miles to the east of Dandot, coal occurs in the plateau overlooking the village of Bhaganwala. As a rule the rocks dip at very low angles, but dips of as much as 45° are occasionally encountered. The seam varies from 0 to 7 feet in thickness and the coal is of variable but usually poor quality. It is very pyritous, and fires induced by the decomposition of that mineral have occurred in the underground workings of the mines.

The area of the plateau beneath which the coal occurs is about 7 square miles. In 1864 Dr. Oldham considered that about 60,000 tons of coal were available. In 1893, however, Mr. Luckstedt, Executive Engineer, North-Western Railway, estimated that the total amount of coal was 20 million tons. In the same year, Mr. T. D. LaTouche,[3] after a careful examination of the field, found that the amount of proved coal was 88,480 tons, and that about $\frac{3}{4}$ million tons might be counted upon.

Between 1877 and 1893, about 2,000 tons were extracted from the coal outcrops by native contractors. About 1893 mining was commenced

[1] *Jour. As. Soc. Beng.*, VII, 848, (1838).
[2] *Sel. Rec. Govt. Ind.*, LXIV, 126, (1868).
[3] *Rec., G. S. I.*, Vol. XXVII, 16, (1894).

by the North-Western Railway Company, and some three years later this company completed a branch line, 10 miles in length, between the collieries and Haranpur, Sind-Sagar Railway. The maximum output from the mines was produced in 1897, when 13,145 tons were raised. In 1899-1900, owing to the poor quality of the fuel being mined, the collieries were closed down.

Dandot.—The Dandot plateau is one of the few localities in which the coal deposits of the Salt Range have been found to be economically workable. It is situated in the Pind-Dadan-Khan sub-division of the Jhelum district, at a height of more than 2,000 feet above sea-level. The coal seam occurs a few feet below the nummulitic limestone, and varies in thickness from 18 to 39 inches. The deposit is roughly basin-shaped, the rocks dipping at angles of from 0° to 14°. In 1887, R. D. Oldham[1] estimated that the plateau had an area of about 2 square miles and contained some 5 million tons of coal. A more recent estimate by Mr. E. L. Hope, the late manager of the colliery, considerably reduced this amount.

The coal is a friable lignite and is much jointed. An assay made in the laboratory of the Geological Survey of India showed that a sample had the following composition:—

Moisture	6·13
Volatile matter	36·81
Fixed carbon	47·17
Ash	9·89

The general run of the coal, however, is probably considerably inferior to this. It contains a large percentage of sulphur as iron-pyrites, and is very liable to spontaneous combustion. Experiments made in 1881 at the Rawalpindi Gas Works[2] showed a production from picked coal of 10,900 cubic feet of gas of 12½ candle-power with a yield of poor sulphurous coke.

Mines are worked at Dandot and at Pidh, about 3 miles to the north-east, by the North-Western Railway Company. They have been in operation since 1884. The production during 1910 was 47,000 tons, the output showing a gradual decline since the year 1899, when 81,218 tons were raised. In 1911 the North-Western Railway Company finally abandoned the mines, which were taken over by local contractors.

[1] MS. report, Geol. Surv. Ind., (1887).
[2] *Rec., G. S. I.*, XV, 63, (1882).

Fig. 1. BRIDGE ON SURFACE INCLINE.
DANDOT, PUNJAB.

R. R. Simpson, Photo. G. S. I., Calcutta.

Fig. 2. DROP-PIT, DANDOT COLLIERY, PUNJAB.

Isa Khel.—These deposits are situated in the Trans-Indus extension of the Salt Range in the neighbourhood of Isa Khel, in the Mianwali district. They were condemned as permanent sources of fuel by Oldham in 1864, but a later examination by R. R. Simpson[1] gives hope that in at least one locality, apparently only superficially examined by Oldham, mines might be established successfully.

The coal is of two geological ages. The Jurassic or older beds attain their best development near the Indus in two localities in the neighbourhood of Kalabagh and Kuch. The seams are thin and inconstant, but it has been calculated that about 86,000 tons are available. Workings in these deposits have been carried on spasmodically for many years, but the total quantity extracted is insignificant. About 1,000 tons are said to have been mined in 1902.

The younger coal, probably of Tertiary age, can be traced as a fairly continuous seam with an average thickness of 27 inches, between the Barochi pass near Mulla Khel to a point due west of Sultan Khel, a distance of about 6½ miles. It has been calculated that nearly half a million tons might be extracted from above the natural water level. In order to bring this coal to market a tram-line 16 miles in length would require to be constructed between the mines and the Indus at Kummure, from whence the coal would be carried up the Indus in barges, a further 16 miles to Mari, the terminal station of the Daud-Khel branch of the Kundian-Campbellpur section of the North-Western Railway Company.

In 1903 a mine was opened at Makarwal, the coal being carried on camels to Kamar Mashami on the Indus river, a distance of 7 miles.

The Isa Khel coals are bright-black, fairly hard lignites; the following are representative analyses:—

	Kalabagh.	Kuch.	Mulla Khel-Sultan Khel. (Average of 21 samples.)
Moisture	4·04	10·19	9
Volatile matter . . .	24·16	22·74	37
Fixed carbon . . .	42·29	46·12	40
Ash	25·12	18·60	10
Sulphur	4·39	2·35	4

[1] *Rec., G. S. I.*, XXXI, 9, (1904).

Choi, Attock.—Nests of nummulitic coal near Attock have frequently excited attention. In 1883 the deposits near Choi, in the Chita range, 10 miles south of Attock, were thoroughly examined by means of borings.[1] No workable coal seam was discovered.

Dore Valley, Hazara.—In the hilly country of Hazara the nummulitic coal horizon frequently comes to the surface. The coal seam varies in thickness from nothing up to at least 17 feet, and it, together with the containing rocks, is much crushed and contorted.

In 1883 and 1888 drifts were made on the outcrops in the Dore ravine and about 7,000 maunds of coal were extracted and carried to Abbottabad, where the fuel was used for lime and brick burning. The difficulty of transport joined to that of working so irregular a deposit was sufficient to render the enterprise a financial failure. The analyses[2] of samples taken foot by foot from the 17-foot outcrop at Begarmul, near Juswal, yielded on the average 40 per cent. of ash, whilst the best individual sample gave 17 per cent.

Kalka.—The existence of very thin strings of coal in the Simla district has been known for very many years. The best exposure, according to C. L. Griesbach,[3] is near Kalka, in the valley of the Kassaulia stream, about 1½ miles up-stream from Tipra, and 1 mile west-south-west from Datiar Chauki on the Simla-Kalka Road. The seam has an average thickness of from 2 to 3 inches, but at one point it is from 8 to 12 inches thick. The quality is fair, but there is not enough of the fuel to warrant working.

(xviii). Rajputana.

Palana, Bikanir.—Late in 1896 coal was discovered during the sinking of a well at Palana, 13 miles south-west of Bikanir. The locality was visited in 1897 by T. D. LaTouche of the Geological Survey of India, who reported[4] that the coal seam occurs at a depth of 212 feet from the surface, is from 4 to 8 feet thick, is directly overlain by nummulitic limestone, and is, therefore, of eocene age. As the country for many miles round Palana is a sandy desert, no estimate of the extent of the deposit could be hazarded.

[1] Scott, G. F.: *Rec., G. S. I.*, Vol. XVII, 73, (1884).
[2] Middlemiss, C. S.: *Mem., G. S. I.*, Vol. XXVI, 289, (1896).
[3] *Rec., G. S. I.*, Vol. XXV, p. 7, (1892).
[4] *Rec., G. S. I.*, XXX, 122, (1897); *Gen. Rep., G. S. I.*, 1898-99, p. 33, (1899).

In 1898 mining operations[1] were commenced in a second well, situated 1,500 feet from the first, where the seam was found to have a thickness of 20 feet. A winding shaft was subsequently put down and a working colliery established and connected by a branch line, 10 miles in length, to the main line of the Jodhpur-Bikanir Railway.

According to information supplied in 1905 by Mr. G. Dixon, for some time the manager of the colliery for Messrs. Bird & Co., the lessees, the seam has been followed for some 1,500 feet to the west of the winding shaft, the thickness of coal being about 30 feet throughout. On the south a fault has been met with at a point 600 feet from the winding shaft. On the north inferior coal was encountered and no work is proceeding in this direction. A pit situated some 1,900 feet north of the winding shaft proved only 3 feet of coal. A prospecting pit is now being put down at a point about 1 mile west of the present working shafts. The method of working consists in dividing the seam into pillars 100 feet square, only the bottom section, 8 feet thick, being mined at present. Owing to the soft nature of the coal and overlying strata expensive timbering operations are necessitated. As the seam is flat and the coal horizon lies nearly 100 feet above the water-level of the country, the mines are completely dry.

In 1901 a boring[2] was put down under the direction of the Geological Survey of India, with the object of proving whether other coal seams existed. The original intention was to bore to a depth of 1,000 feet, but the contractors were unable to reach much more than half of that depth, and the negative result attained was, therefore, indecisive. The coal is a resinous, woody lignite of a brown-black colour. On exposure to the air it rapidly oxidizes and splits up, heat being produced during the process. Owing to this cause what might, but for prompt measures, have proved a disastrous fire occurred in the underground workings of the colliery in 1898. By reason of the lightness of the fuel difficulty was at first experienced in burning it in locomotives with grates designed for burning the heavy Bengal coal. On the introduction of a more suitably designed grate this difficulty was overcome. Experiments have been made with the object of reducing the large percentage of

[1] R. W. Clarke : *Trans. Fed. Inst. Min. Mech. Eng.*, Newcastle, XXII, (1901-02).
[2] *General Report, Geol. Surv. Ind.*, p. 14, (1901-02).

moisture in the fuel and rendering it impervious to atmospheric influences. These experiments have taken the form of a special process of briquetting in which no binding agent is employed, but the particles of ground and dried coal are induced to adhere to one another by the sole agency of compression at a pressure of from 10 to 12 tons per square inch in specially designed machines. It is proposed to import elaborate plant from Europe and to convert a large proportion of the output into briquettes. Samples of briquettes supplied to the Geological Survey of India in 1904 were of a hard texture, and had a glazed superficial crust which appeared to be well adapted to resist the action of atmospheric agencies. Analyses of the coal and briquettes gave the following results :—

	Coal.	Briquette (No. 1).	Briquette (No. 2).
Moisture	22·90	14·84	9·32
Volatile matter . . .	35·36	40·64	44·36
Fixed carbon . . .	38·16	38·78	38·80
Ash	3·58	5·74	7·52

In 1911 the output from the colliery was 12,744 tons, the decline in quantity since 1904 being fourfold.

(xix). United Provinces.

Carbonaceous deposits of young Tertiary age have been frequently noticed in the Sub-Himalayan rocks. Sir Probyn Cautley[1] appears to have been the first to draw attention to these deposits, which he did in the year 1828. At Silani, under Nahan, seams of coaly matter of from half an inch to three inches thick were discovered, and at the Kalawala Pass leading into Dehra Dun accumulations of vegetable matter turned into lignite were found in two localities. Captain Herbert[2] apparently refers to the same locality as the Timli Pass, and he states that the substances had the appearance of common charcoal with the woody structure well preserved. At the Kheri Pass carbonaceous matter occurred both in seams and as imbedded logs or stumps. Another locality is in the bed of the Bulia near Bhamauri and near Ranibagh close to Hulduani.

[1] *As. Res.*, Vol. XVI, p. 387.
[2] *As. Res.*, Vol. XVI, p. 397.

That from Bhamauri occurred in a seam 4 inches thick; it showed no woody structure, having the appearance of jet, but was very brittle. The composition of Ranibagh coal was:[1] —

Carbon	60·0
Volatile matter	36·4
Ash	3·6

In 1833[2] Mr. E. J. Ravenshaw forwarded samples of lignite and jetty coal from Dhela river in the north of the Moradabad district. These occurred only in thin nests and layers and contained a good deal of iron pyrites.

Mr. Medlicott,[3] in his review of the whole question of these carbonaceous deposits, while anxious not to deter any explorer from investigating so important a subject, points out that the result of experience is unfavourable to the prospect of coal being found in useful quantity.

At a later date C. S. Middlemiss,[4] in his description of the physical geology of the Sub-Himalaya of Garhwal and Kumaun, says: "nests and strings of lignite and coaly material, bright, shining and breaking cuboidally, are very common. They are very small, though occasionally a somewhat larger tree trunk has been fossilized, and given rise to unreasonable expectations of coal. Nothing resembling a seam is known. It may be as well to state, therefore, at once, that there is not the slightest chance of finding workable coal in these hills."

Undeterred by these informed opinions, E. C. Agabeg[5] in 1901, happening across some of these chance exposures, claimed to have discovered Damuda rocks in the hills between Rajpur and the Jumna. A syndicate was formed and boring operations undertaken. They were completely unsuccessful.

[1] *Economic Mineralogy of Hill dist.*, by E. T. Atkinson, p. 32, (1877).
[2] *Jour. As. Soc. Beng.*, Vol. II, p. 264, (1833).
[3] *Mem., G. S. I.*, Vol. III, p. 180, (1864).
[4] *Mem., G. S. I.*, Vol. XXIV, 26, (1890).
[5] *Memo. on the Dehra-Dun coal prospects*, Calcutta, (1905); *Ind. Engineering*, XXXII, 60, (1902).

CHAPTER III.

PRODUCTION, TRADE, LABOUR, ETC.

The significance of the coal industry.

Under the existing conditions governing the world's commerce the magnitude of the coal industry of any country may be taken to be the measure of that country's commercial importance, and the expansion and contraction of the industry is perhaps the best possible gauge of increasing or decreasing prosperity. Since the publication of Mr. Ball's statistical tables[1] in 1881, the coal trade of India has undergone enormous expansion, the significance of which can be appreciated when it is understood that it is directly due to the ever-increasing extensions of her railway system, the growing importance of her manufactures and the advance in her foreign trade. The extent of this development can be appreciated from the following table in which are shown the total production, exports and imports of coal between 1881 and 1910:—

Year.	Imports.	Production.	Exports. (*a*)
1881	805,924	997,730	1
1882	597,334	1,130,242	..
1883	672,151	1,315,976	..
1884	754,641	1,397,818	100
1885	835,658	1,294,221	326
1886	762,154	1,388,487	500

[1] *Manual of the Geology of India*, Vol. III, p. 63, (1881).
(*a*) 1881 to 1888 official years; 1889 to 1910 calendar years.

Year.	Imports.	Production.	Exports.
1887	849,607	1,564,063	159
1888	850,423	1,708,903	300
1889	832,374	1,946,172	51,305
1890	683,305	2,168,521	30,635
1891	775,933	2,328,577	4,061
1892	700,928	2,537,696	15,554
1893	678,532	2,562,001	24,550
1894	766,229	2,823,907	70,556
1895	807,497	3,540,019	75,855
1896	652,522	3,863,698	92,714
1897	269,691	4,066,294	222,129
1898	346,639	4,608,196	315,833
1899	581,329	5,093,260	269,281
1900	154,670	6,118,692	490,490
1901	237,435	6,635,727	587,871
1902	258,026	7,424,402	430,115
1903	192,729	7,438,386	441,938
1904	270,244	8,216,706	602,810
1905	212,575	8,417,739	783,033
1906	232,947	9,783,250	1,002,951

Year.	Imports.	Production.	Exports
1907	302,807	11,147,339	658,145
1908	391,521	12,769,635	659,596
1909	519,981	11,870,064	563,940
1910	332,616	12,047,413	988,366

Imports.

Between 1881 and 1895 the imports of coal into India remained practically stationary. From the latter year a steady decrease set in, until in 1900 the minimum of 154,670 tons was reached. In 1909, largely owing to the high price of coal during the boom of 1908, the quantity increased to half a million tons, but fell again in 1910 to 332,616 tons.

About 77 per cent. of the imported coal comes from the United Kingdom, the rest being fairly equally divided between Japan and Australia. Within recent years attempts have been made to establish an Indian market for Natal coal. No great success has been achieved.

Of the coal used on Indian railways, the foreign article declined in use from 183,654 tons in 1881 to 52,147 tons in 1910, whilst the home product advanced in use from 382,431 tons in 1881 to 3,771,247 tons in 1910.

Production.

It is interesting to notice that the use of wood fuel still obtains on certain sections of the Indian railway system distant from the sources of coal supply. Since 1904 when nearly 400,000 tons were used there has been a marked decline, the amount used in 1910 being only 127,725 tons.

From 1881 to 1894, the production of coal in India slowly and steadily increased in threefold measure. From that year, partly owing to the impetus given by the opening of the Jharia field, the increase has been much more rapid, the figures for 1910 denoting an expansion of twelve times on those for 1881. India has now for some years occupied the proud position of producing a larger quantity of coal than any other British dependency. It is significant that between 1900 and 1902, coincident with a decline in exports of more than 20 per cent., the production of coal in India increased by nearly 18 per cent. This was due to the increased

demand in up-country markets and for railway purposes. It is, therefore, as Lord Curzon has said, to the industrial development of India that we must look for any material expansion in the markets for coal.

The production of the various provinces can be seen from the following table :—

Year.	Assam.	Baluchistan.	Bengal.	Burma.	Central India.	Central Provinces.
1881 . . .	..	..	930,203	..	..	67,527
1882 . . .	..	..	1,038,872	..	..	91,370
1883 . . .	..	..	1,200,957	..	..	115,019
1884 . . .	16,493	..	1,257,392	..	2,100	121,833
1885 . . .	43,707	..	1,123,700	..	7,698	119,116
1886 . . .	70,859	..	1,186,802	..	13,539	117,287
1887 . . .	89,302	411	1,319,090	..	15,497	128,981
1888 . . .	101,528	2,802	1,380,594	..	41,580	157,768
1889 . . .	116,676	8,238	1,541,356	..	52,956	144,465
1890 . . .	145,708	15,541	1,626,245	..	77,842	137,022
1891 . . .	154,208	10,368	1,747,122	..	69,741	141,736
1892 . . .	164,050	13,284	1,920,050	3,670	88,623	132,005
1893 . . .	164,420	20,094	1,902,866	9,938	94,348	135,118
1894 . . .	169,448	24,753	2,035,934	12,111	132,837	140,495
1895 . . .	172,717	25,458	2,716,155	17,289	118,479	122,776
1896 . . .	177,259	26,257	3,037,920	22,993	115,386	141,185
1897 . . .	185,533	12,043	3,142,497	11,472	124,778	131,629
1898 . . .	200,329	13,372	3,622,090	6,975	134,726	149,709
1899 . . .	225,623	15,822	4,035,265	8,105	164,569	156,576
1900 . . .	216,736	23,281	4,978,492	10,228	164,489	172,842
1901 . . .	254,100	24,656	5,487,585	12,466	164,362	191,516
1902 . . .	221,096	33,889	6,259,236	13,302	171,538	196,981
1903 . . .	239,328	46,909	6,361,212	9,306	193,277	159,154
1904 . . .	266,765	49,867	7,063,680	1,105	185,774	139,027
1905 . . .	277,065	41,725	7,234,103	..	157,701	147,265
1906 . . .	285,490	42,164	8,617,820	1,222	170,292	92,848
1907 . . .	295,795	42,488	9,993 348	..	178,588	134,088
1908 . . .	275,224	45,212	11,559,911	..	155,107	213,789
1909 . . .	305,563	52,449	10,660,811	..	121,496	238,100
1910 .	297,236	52,614	10,778,530	..	130,400	220,437

Year.	Hyderabad.	Kashmir.	Madras.	Punjab.	Rajputana.	United Provinces.
1881	..	..	..	..	..	..
1882	..	..	..	..	..	..
1883	..	..	..	..	..	..
1884	..	..	..	..	..	..
1885	..	..	..	..	..	..
1886	..	..	..	..	..	..
1887	3,259	..	..	7,523	..	..
1888	13,382	..	..	11,249	..	..
1889	59,646	..	..	22,835	..	..
1890	125,486	..	..	40,677	..	..
1891	144,668	..	20	60,714	..	..
1892	149,601	..	61	66,352	..	..
1893	157,421	..	502	77,294	..	..
1894	240,525	..	1,337	66,467	..	..
1895	292,915	..	1,737	72,493	..	..
1896	262,681	..	..	79,017	..	1,000
1897	365,550	..	..	92,792	..	..
1898	394,622	..	..	85,862	511	..
1899	401,216	..	..	81,835	4,249	..
1900	469,291	..	..	74,083	9,250	..
1901	421,218	..	..	67,730	12,094	..
1902	455,424	1,060	..	55,373	16,503	..
1903	362,733	999	..	43,704	21,764	..
1904	419,546	270	..	45,594	45,078	..
1905	454,294	..	..	62,622	42,964	..
1906	467,923	..	..	73,119	32,372	..
1907	414,221	..	..	60,749	28,062	..
1908	444,211	..	..	54,794	21,297	..
1909	442,892	..	..	37,208	11,449	..
1910	506,173	..	..	49,189	12,744	..

It will be noticed that 90 per cent. of the output is produced in the Bengal (Bihar and Orissa) fields. Owing to the wide extent of the latter, the fair quality of coal which they contain and their comparative nearness to the sea-coast, this proportion is not likely to decrease in the near future.

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Exports.

The Indian coal export trade dates from 1884, but only assumed importance five years later when 51,305 tons of coal were shipped to foreign ports, chiefly Ceylon and Singapore. In 1901 coal exports exceeded half a million tons, and the amount for 1910 was 988,366 tons. In the same year the principal shipments were to Ceylon (534,582 tons), Singapore (148,640 tons), Penang (89,815 tons), Sabang Bay (106,291 tons) and Australia (74,340 tons). This latter shipment was due to a strike in the Australian coalfields. Small quantities were also sent to Batavia, Aden, Mauritius and Trinidad. In former years cargoes have been exported to British East Africa, Natal, Java, New Zealand, the Philippines, Arabia, Somaliland, Egypt and Madagascar.

Practically the whole of the coal exported from India is shipped from Calcutta. For some years past the merchants of that port have been making strenuous efforts to drive foreign coal out of the eastern markets. The competitors with Bengal for these markets are England, Japan and Australia, and the struggle is most keen at the ports of Bombay, Colombo and Singapore. At Bombay English coal is the only serious rival of the Bengal fuel. Owing to its superior quality it is probable that for certain purposes, *i.e.*, war-ships, mail-steamers, etc., English coal will always command a small market.

The freight rate from Cardiff to Bombay varies from 9*s*. to 14*s*. per ton, and the rise in the imports from England, which has taken place since 1903, is largely due to the extremely low freights prevailing between Cardiff and Bombay. The Calcutta-Bombay freight varies from Rs. 4 to Rs. 6-8, but exporters are handicapped by the difficulty of securing return freights from Bombay. At the present time (October, 1911) the prices per ton in Bombay *ex ship* are Rs. 12 for Indian, and Rs. 16 to Rs. 20 for English coal.

It is significant that while English coal has merely held its own in the Colombo market due to the special purposes for which it is required, yet the imports of Australia and Japan have occasionally gained ground. This is due to the fact that the Australian fuel is slightly superior to the best Bengal coal and that in both cases the coal is brought as a return cargo. The decline in Bengal shipments following on the boom years 1902 and 1908 was largely owing to the inferior quality of much of the fuel shipped in former years, and the resulting bad name which it acquired. Shippers are

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COAL CARRIERS EMERGING FROM AN INCLINED DRIFT, KALIPAHARI, RANIGANJ COAL-FIELD.

Selling prices.

Selling prices also vary considerably. In 1911 the average price per ton in wagons at the colliery was Rs. 3-12 as. to Rs. 4-8 as. in the Raniganj field, Rs. 2-6 as. to Rs. 3 in the Jharia field, and Rs. 3-4 as. in the Giridih field. In Central India and the Central Provinces the selling price varies from Rs. 3-8 as. to Rs. 7.

The figures for costs, selling prices and freights appended were those prevailing in October 1911.

	Rs. A. P.		Rs. A. P.
Total cost of Raniganj coal at mine	1 14 0	to	2 8 0
Total cost of Jharia coal at mine	1 8 0	,,	2 0 0
Selling price of Raniganj coal at mine	3 12 0	,,	4 8 0
Selling price of Jharia coal at mine	2 6 0	,,	3 0 0

	Rs. A. P.		Rs. A. P.
Railway freight, Raniganj to Calcutta	2 9 0	Less shipment rebate . . .	2 0 0
Railway freight, Jharia to Calcutta	3 2 0	,, ,, . . .	2 8 0
Railway freight, Raniganj to Bombay	11 4 0		
Railway freight, Jharia to Bombay	11 4 0		

	1910.	1911.		
	Rs. A. P.	Rs. A. P.		Rs. A. P.
Sea freight, Calcutta to Singapore	3 8 0	4 4 0	to	5 0 0
,, ,, ,, Colombo .	3 12 0	4 4 0	,,	5 0 0
,, ,, ,, Bombay .	4 12 0	5 12 0	,,	6 8 0
,, Cardiff to Bombay.		s. 10	to	s. d. 10 6

	Rs. A. P.	
Selling price of export coal in Calcutta	6 4 0	f. o. b. Calcutta.
Selling price of export coal landed in Singapore	10 0 0	c. f. i.
Selling price of export coal landed in Colombo	10 8 0	c. f. i.
Selling price of export coal landed in Bombay	12 0 0	c. f. i.

Methods of mining.

The almost universal practice in Indian coal mines is to extract the coal on the system variously known as the "bord and pillar," "post and stall" or "stoop and room" system. Although this system in Europe, except under special circumstances, is fast being superseded by

the more economical "longwall" method, yet, owing to the thickness of the majority of Indian coal seams, it is not easy to devise any more suitable plan of working. It is undoubtedly wasteful, for the pillars form from 25 to 65 per cent. of the available coal, and at the present time their extraction is undertaken at only a limited number of mines. In the early days, and even now, at certain collieries, extremely small pillars were left to support the excavations; with the result that after some time serious subsidences occurred, and not infrequently lives were lost. Under the present more enlightened management, however, these occurrences are likely to become fewer. In the Giridih field an extraction of more than 90 per cent. is obtained from a seam, 21 feet thick, with an exceptionally strong roof. The pillars are formed in the lower part of the seam, and by an ingenious arrangement of vertical cuts, aided by the use of high explosives, successive areas of the top coal 40 feet square are dropped, and filled away before the roof shows signs of breaking. The system has since been introduced with success in the Jharia coalfield.

In the Raniganj field a thin seam was worked for some years on the longwall method with the use of disc coal cutters and a mechanical conveyor. With the decline in prices which followed the coal boom of 1907-08 the cost was found to be prohibitive and the experiment was given up in 1910.

During the same period of inflated prices and scarcity of labour mechanical coal cutters of the pick type were introduced in a number of Bengal mines. Their use has since declined, but they are still employed in development work at a few collieries.

At the Singareni collieries longwall working is practised to a small extent, and a few years ago the extraction of small pillars by a system of hydraulic or water-introduced packing was tried but abandoned on the score of excessive cost.

In the Jharia coalfield a highly inclined coal seam 100 feet in thickness is being worked by a system of horizontal slices with fair success. In the same coalfield thick seams lying at a moderate inclination are being worked in stages with unworked layers of solid coal between.

In the Makum coalfield (Assam), a highly-inclined seam, 75 feet thick, is worked on a modification of the South Staffordshire system of "square work." The coal is removed in two or sometimes three sections, the top section being removed first, and a parting

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WINDING GIN, NEAR CHARANPUR. RANIGANJ COAL-FIELD.

of stone and coal being left untouched between each pair of sections. The work is exceptionally difficult as the seam is very liable to spontaneous combustion; and "bumps" due to the disturbance of equilibrium caused by the working of the coal occur.

In the Dandot (Punjab) and Khost (Baluchistan) coal-mines, thin seams are worked in one operation on a modified "longwall" system which appears to be fairly successful.

Except in a few localities the amount of water in Indian collieries is not large, and considering the shallow depths attained up to the present, does not constitute a serious expenditure for pumping operations. In this connection, however, a word of warning may be given to mine-owners. The almost universal practice in India has been to work out the whole of the outcrop coal without leaving any barrier to prevent the influx of surface water. The result of this short-sighted policy must be that in the deeper workings of the future, the mine-owner will be burdened with the expense of pumping practically the whole of the outcrop water, an expense which will become greater the deeper mining operations are carried on. The evil is so great that Government have had to consider whether some form of State interference is not called for in order to prevent the possible loss of coal which may ensue.

Use of machinery.

It is satisfactory to note that the use of machinery, particularly during the last ten years, is rapidly extending. At the larger collieries modern plants of good design are now the rule rather than the exception. At the smaller, chiefly native-owned mines, however, there is much need of improvement. It may be a surprise to many to know that, at the present day, within 120 miles of Calcutta, a coal-winding gin, driven by coolie women, can be seen in daily operation (Plate 16).

Labour.

During the quinquennial period of 1904—1908, the average number of persons employed in and about the coal-mines of India was 104,709. The great proportion of those employed are the aboriginal Dravidians from the mountainous country of Chota Nagpur and the Central Provinces, but a large number of other castes are employed, particularly in the outlying fields. The majority of the workmen are employed in agriculture as well as mining, and make a practice of returning to their homes during the periods of sowing and reaping; the result being that, at such times, the output of many of the mines is greatly restricted. In certain long-established mining centres

however, a population, wholly devoted to the pursuit of mining, is being built up. The provision of allotments of land for working miners is one of the corner stones of the industrial system in the Giridih coalfield.

Between the years 1904 and 1908 the output of coal per person employed averaged 96 tons. This is an increase of 31 per cent. on the average of the preceding quinquennial period. In 1910 the figure was 103·7 tons. There is great variation in the figures for different coalfields, the amounts varying in 1910 from 27·6 tons at Dandot (Punjab) to 154·4 tons at Makum (Assam).

Over the same quinquennial period there were 10·2 lives lost per million tons of coal raised, and the death-rate per thousand persons employed was 0·98.

Legislation.

After many years of deliberation, the first step in the direction of the Government regulation of mines was taken in March 1901, when Act No. VIII of 1901, an Act to provide for the regulation and inspection of mines, received the assent of the Governor-General in Council. A year later a Mining Board of five members, as provided for in the Mines Act, was formed for the lower provinces of Bengal.

As the result of the Board's labours, a code of rules for the regulation of coal mines in British India was drawn up, and became law on the 10th of March 1904. These rules are 26 in number and deal with (1) single shafts or outlets, (2) raising and lowering persons, (3) roads and working places, (4) plans, (5) explosives, (6) ventilation and lighting, (7) miscellaneous. Rules relating to mine managers and their certificates were passed into law in 1906. The establishment of a code of special rules for the control and guidance of persons employed in coal mines was initiated in 1911.

Mines inspection.

From 1894 the inspection of mines was carried on in a somewhat semi-official manner, the inspectors having small legal powers and chiefly confining their energies to the offering of advice to mine-owners and managers, and the collection of statistics and information for the use of Government. This preliminary period was, doubtless, of good service in preparing the minds of those interested in the mining industry for the passing of the Mines Act and Rules. In January 1902, the control of the Inspectors by the Geological Survey Department was given up and a Department of Mines was formed. The staff now consists of a Chief Inspector and three Inspectors.

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Indian Mining Association.

In 1892, the merchants of Calcutta interested in the coal industry met together and formed for their mutual advantage a combination known as the Indian Mining Association. The objects of this Association are "to protect by every legitimate means the interests of those engaged in developing the mining industries of India, to foster those industries, to provide a ready means of arbitration for the settlement of disputes between mining proprietors, and to take part in such discussions affecting land as may have a bearing on mines, their development or working, and for this purpose to enter into communication with the Government and other public bodies."

During the twenty years of its existence the Association has proved its usefulness in numerous ways. In the drafting of mining legislation its opinion and advice have always considerable weight. Its united action in trading with railway companies and the officials of the port of Calcutta has met with marked success. Its co-operative medical association, to which many of the European and some Indian coal companies in the Raniganj and Jharia fields subscribe, supplies a pressing want, and has done much to improve the conditions of existence in those coalfields.

CHAPTER IV.

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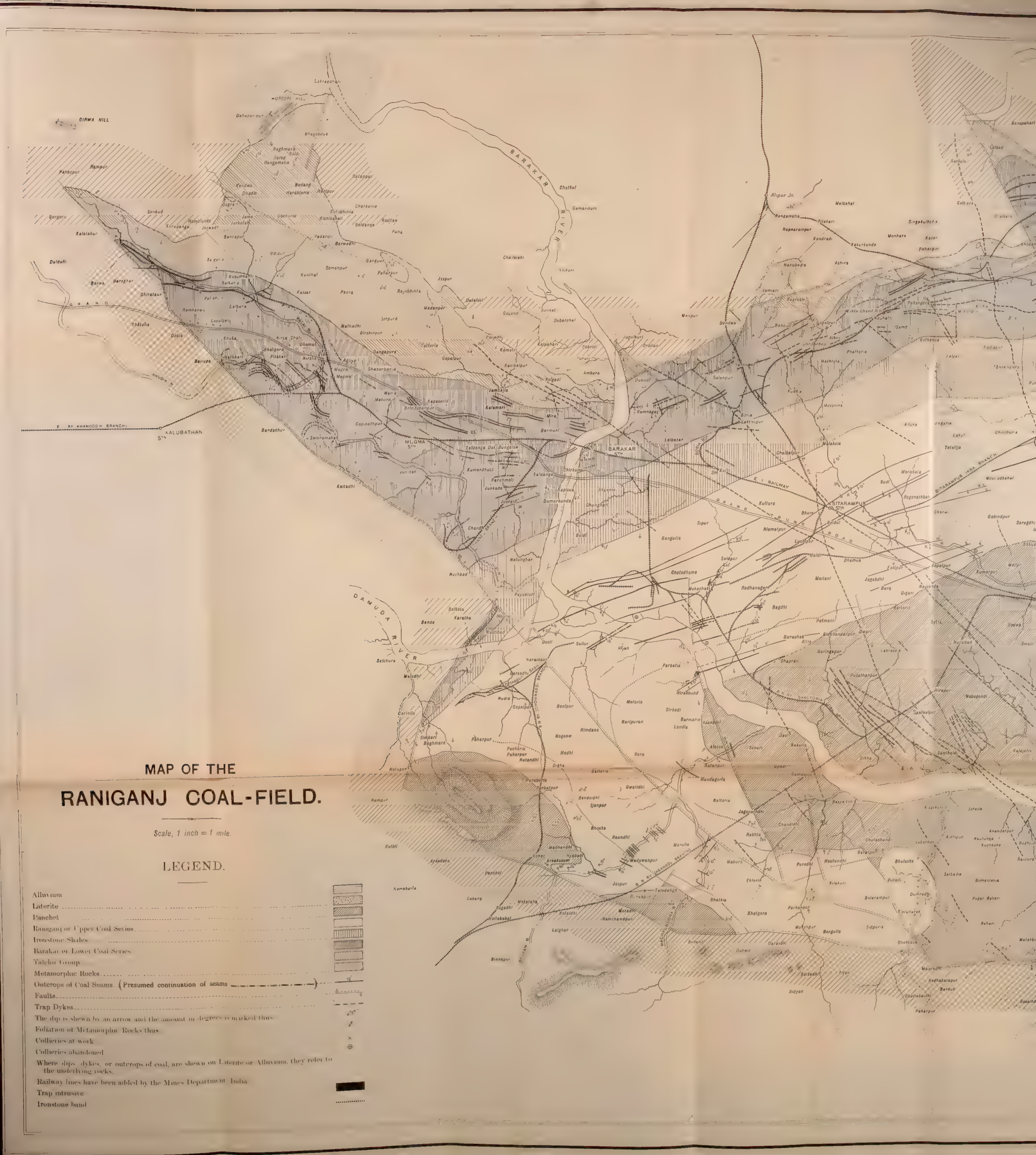
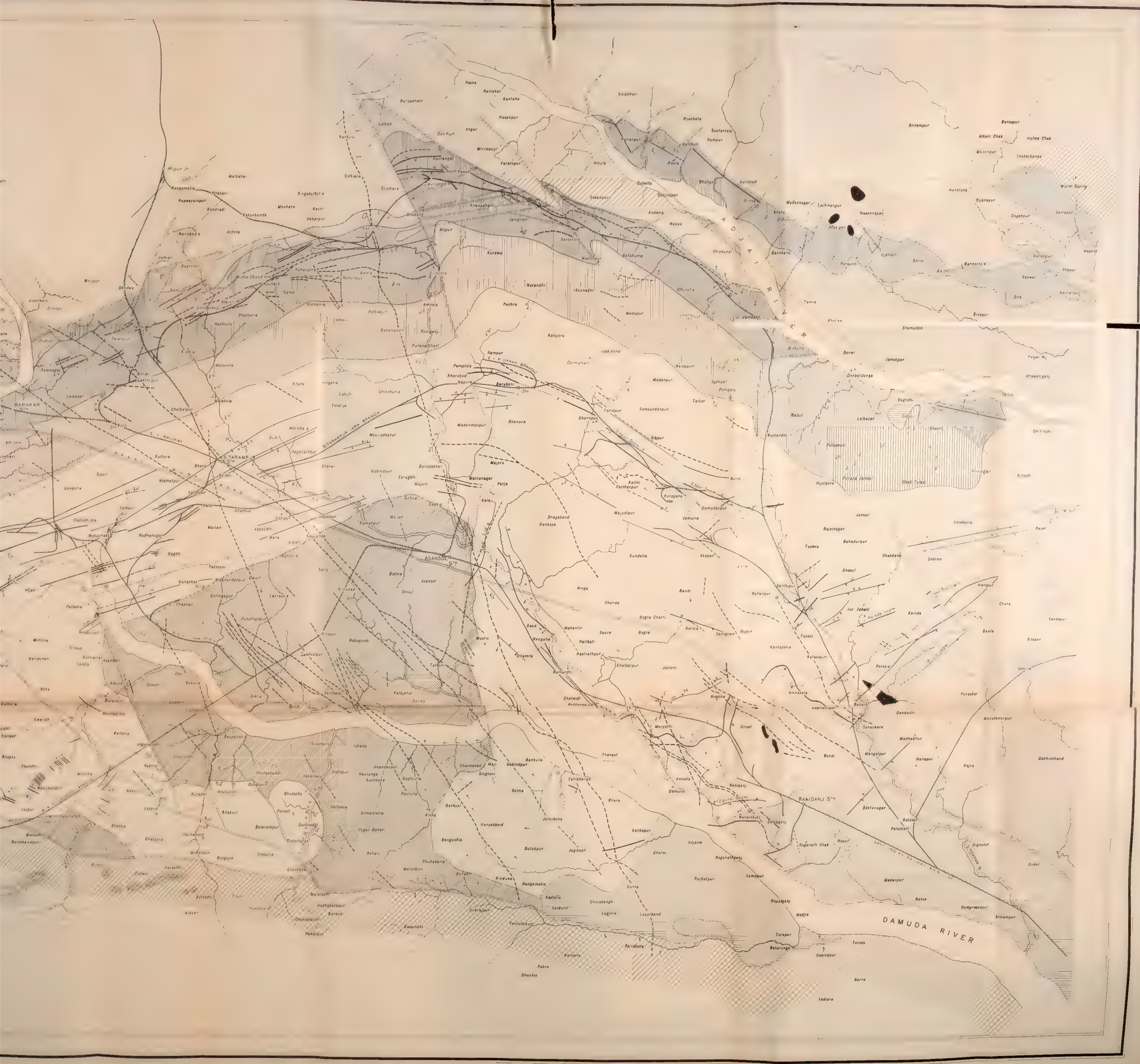

MAP OF THE
RANIGANJ COAL-FIELD.
Scale, 1 inch = 1 mile.
LEGEND.
Alluvium
Laterite
Panchet
Raniganj or Upper Coal Series
Ironstone Shales
Barakar or Lower Coal Series
Talchir Group
Metamorphic Rocks
Outcrops of Coal Seams. (Presumed continuation of seams
Faults
Trap Dykes
The dip is shewn by an arrow and the amount in degrees is marked thus
Foliation of Metamorphic Rocks thus
Collieries at work
Collieries abandoned
Where dips, dykes, or outcrops of coal, are shewn on Laterite or Alluvium, they refer to the underlying rocks.
Railway lines have been added by the Mines Department, India.
Trap intrusive
Ironstone band
BARAKAR RIVER
DAMUDA RIVER
BARAKAR STN
SITARAMPUR STN
KALUBATHAN STN
GRAND TRUNK ROAD
E. I. RAILWAY


ADJAI RIVER
DAMUDA RIVER
ASANSOL STN
RANIGANJ STN
BARAKAR
SITARAMPUR STN


MAP
OF THE
JHARIA COAL-FIELD.
Compiled from map by the
Late T. W. H. Hughes (Mem. G. S. I., Vol. V),
Revised by T. H. Ward (Rec. G. S. I., Vol. XXV), and
Again revised by G. A. Stonier.
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Coal seams are shown by a black line
Dip is shown by an arrow 30°, and the amount is given in degrees
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Dumra
Chandor
Singra
Dooga
Rampokhar
CHASH
Sealjuri
Chatatand
Debagram
Parasbanian
Suranga
Seraidhela
Barwa
Haichar

Madras

1 [illegible]
2 [illegible] Damercherla
3 [illegible]

[illegible] Nizam's Territory

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MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA

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VOLUME XLI, PART 2.

ON THE GEOLOGY AND COAL RESOURCES OF KOREA STATE, CENTRAL PROVINCES. *By* L. LEIGH FERMOR, D.SC., A.R.S.M., F.G.S., *Superintendent, Geological Survey of India. (With 12 plates.)*

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CHAPTER I.

I.—INTRODUCTION

General.

The only account of the coalfields of Korea State previously published is contained in T. W. H. Hughes' Memoir entitled 'The Southern Coal-fields of the Rewah Gondwáná Basin: Umaria, Kórár, Jóhilla, Sohágpúr, Kúrásia, Koréágarh, Jhilmili', issued in 1885 as part 3, Volume XXI, of the Memoirs of the Geological Survey of India; but a preliminary paper by the same author contains references to the Korean granite and to the Talchirs of Kulharia Nala [*Records, G. S. I.*, XIV, pp. 311, 312, 317, (1881)]. Of the coalfields enumerated in the title of the memoir cited, two, namely Kurasia and Koreagarh, lie entirely within the limits of Korea State, whilst the eastern end of the Sohagpur field, the main portion of which is situated in Rewah State, also lies in Korea. Owing, no doubt, to the relatively inaccessible situation of this State, no attention seems to have been given to the possibility of developing its coal resources until 1911, when Mr. E. H. Blakesley, Political Agent to the Chhattisgarh Feudatory States, pointed out the desirability of investigating the capabilities of the Korean seams. For this purpose the Government of the Central Provinces engaged Mr. J. L. Harris, of Kamptee, who, after a tour in the State lasting from December 1911 to February 1912, submitted a report dated the 15th

July 1912. In addition to visiting a considerable number of coal outcrops, the positions of most of which had apparently already been ascertained by villagers, Mr. Harris devoted some attention to the possible alignment of a branch railway into Korea from Jaithari station on the Katni-Bilaspur branch of the Bengal-Nagpur Railway. He also discusses the possible routes for roads; for except near Baikanthpur and in the western portion of the State, between Ghutra and Kelhari, Korea is at present practically devoid of any tracks, except those adapted to cooly and bullock transport.

Mr. Harris' report, in which are given a certain number of analyses, indicates the probability of some of the coal seams being of value, and to test these probabilities he recommends boring operations in various localities, the sites of the bore holes suggested being marked on his map. This report is the property of the Government of the Central Provinces.

Owing to the favourable character of Mr. Harris' report I was deputed by the Director of the Geological Survey of India to visit Korea during January and February 1913. Although my visit was a short one, yet the information obtained, of which a summary is presented in these notes, is sufficient to enable me, in agreement with Mr. Harris, to express the opinion that boring operations are likely to prove the existence of workable coal seams both along the southern edge of the Sanhat[1] (Sohagpur) field, and in the Kurasia field. I did not visit the small Koreagarh field, as neither Hughes' memoir nor Mr. Harris' report records the existence therein of any important coal seams; but it should be understood that no examination of this field more than cursory has yet been made, and that it by no means follows that workable coal seams are non-existent therein.

Names of the coalfields.

Before proceeding further, it will be convenient to discuss the nomenclature of the coalfields in Korea State. In his memoir, Hughes definitely assigns the names Kurasia and Koreagarh to the two smaller fields. The third coal area is the eastern extension of the Sohagpur coalfield, and in assigning the name Sohagpur to the whole of this field, comprising nearly 1,600 sq. miles, Hughes says (p. 177):—

'It may hereafter be found convenient to introduce some restricted local designations. The portion within the Korea district appears suggestive

[1] See page 150.

of such a course, but I have no doubt that the adjustment of names and titles will be satisfactorily carried out when the necessity arises.'

It now seems desirable to assign a separate name to that portion of the Sohagpur field lying within Korea State, and, for such a purpose, no name seems more suitable than that of *Sanhat*, the former capital of the State, situated upon this field. In this paper I shall, therefore, refer to this eastward extension of the Sohagpur coalfield as the *Sanhat coalfield.*

The Sanhat field.

In their survey of this State carried out in the early eighties, Messrs. Hughes and Hira Lal examined all the important streams traversing the northern or Sanhat coalfield, with the resultant discovery of numerous outcrops, the positions of which are marked on the map of the coalfields of the Rewah Gondwana basin accompanying Hughes' memoir. The positions of these outcrops are also given in the *Appendix of Coal Sites* on pp. 236-245 of the same memoir. The Korean localities are repeated in Appendix II of the present paper. With reference to this work Hughes says (p. 201) :—

'To obtain a standard section my colleague and myself ascended most of the streams, large and little, which, curiously enough, have their watershed nearly coincident with the upper limit of the productive measures, but there was in each instance too much incompleteness in the sequence of the rocks to secure this result.'

From this it is evident that Hughes and Hira Lal were unable to correlate the seams exposed in various streams ; and, as the time at my disposal permitted me to visit only a small proportion of the exposures, I must confess myself equally unable to correlate with any certainty the coal outcrops of the Sanhat field. My visit must, therefore, be regarded as a reconnaissance for the purpose of ascertaining whether or no the outcrops indicate the possible existence of seams of coal of sufficient thickness and high enough quality to be workable. Nothing except boring operations aided by the most careful examination of every minute nala will enable this correlation to be successfully effected. Nevertheless, as a possible help to future works, I have ventured to put forward a tentative correlation (see Table 6, page 190, and Appendix No. I).

The Kurasia field.

In the Kurasia field, on the other hand, Hughes and Hira Lal were able to make only a most cursory examination. Consequently I devoted to portions of this field a considerable portion of the time at my disposal. I examined a large number of outcrops of coal, both

those known to the local inhabitants and also several discovered by myself; and, as a result I am convinced that, were time allotted for a detailed and careful survey of this field, it would be possible to correlate with some accuracy the coal seams exposed. On a map (Plate 30) of the country round the villages of Kurasia and Chirmiri on this field, I have indicated all the coal outcrops examined, and in the text (pages 188, 196, 197, 201, 202 and Appendix No. I), have suggested their possible correlation.

The reason for the difference between the Sanhat and Kurasia fields in this respect (possibility of correlating seams) lies in the more hilly nature of the Kurasia field, on account of which the coal seams are less often obscured by alluvial material than in the northern field.

Geological map.

In addition to the plan of the Kurasia field referred to above I reproduce with this report that portion of the geological map of the Rewah Gondwana basin, given in Hughes' memoir, that relates to the Korea State (Plate 31) south of Lat. 23°30'N. I entered the State at its south-western corner near Jaraunda, and marched north-eastwards through Khargaon, Chirmiri, Kurasia, and Banjaridand, to Baikanthpur, Dewadand, the new capital of the State; thence I proceeded northwards to Rakeya, and then westwards along the southern edge of the Sanhat field, as far as Ghutra, whence I marched southwards down the Hasdo valley by Balbahara, Karimati, and Banji, finally leaving the State at Kora on my way back to Pendra Road. This tour enabled me to test the accuracy of my predecessors' map at many points, and I find myself in complete agreement therewith, except for a few trivial differences. Consequently their map is repeated in this paper without any modification of the geological boundaries. But I have omitted the coal seams as shown on their map, inserting instead on the Sanhat field serial numbers corresponding to the outcrops enumerated in Appendix I. The coal outcrops visited by me in the Kurasia field are shown in the larger-scale map (Plate 30) by numbers corresponding to those in the same Appendix.

Coal samples.

In the task of reducing my coal samples to manageable bulk, I received considerable help from Babu Bankim Bihari Gupta, Field Collector of the Geological Survey, and on my departure southwards from Ghutra I

despatched him westwards to take samples of coal from the localities of Putadand, Bahi, Kerabahara, Kelhari, and Bichatola. The method of sampling adopted was, where possible, to take a vertical cut through the seam at its outcrop and to reduce the coal thus obtained to both smaller size and bulk by the ordinary methods of coning and quartering. The coal was often very dirty and wet, owing to its mode of occurrence, and in these cases the coal obtained was washed by hand and dried in the sun before being broken down. The results of the analyses of these samples carried out in the laboratory of the Geological Survey by Mahadeo Ram are given on pages 191, 192, 193, 199, 203, 206, and, in estimating their value, allowance should be made for the fact that they are outcrop coals only, and that when obtained from the interior of the seam the samples would probably show less moisture and a little less ash.

Other formations.

In addition to the Barakar and Talchir divisions of the Gondwana system my tour enabled me to examine several of the inliers of Archæan rocks—namely, those of Phunga, Khargaon, Salba, Patna, Siroli, and Karimati—as well as the large sill and many of the dykes of Deccan Trap age indicated on the map.

Deccan Trap.

The most interesting point about the traps is that there is not, so far as I discovered, a single patch of Deccan Trap of extrusive character, the irregular strip running E. N. E. across the State, being a giant intrusive sill. Both it and all the dykes examined are composed of dolerite of various degrees of coarseness, sometimes free from, and sometimes rich in olivine.

Archæan rocks.

The Archæan rocks examined consist very largely of granites, gneisses, and schists, which can be matched, nearly or exactly, with specimens collected in the Chhindwara district some 230 miles further to the W. S. W., indicating that the State of Korea lies on the eastern extension of the Archæan core of the Satpura Range. These outliers of Archæan rocks being of such variable composition and my examination of them being cursory I do not propose to enter into any detail in their description, but merely to enumerate the rocks found and state their resemblances to, and differences from, their nearest analogues in the Chhindwara district.

Pendra *zamindari*.[1]

In my journeys through the Pendra *zamindari*, from Pendra Road to Korea State and back again, which lay almost entirely across Archæan country largely obscured by the alluvium of the Son river and its tributaries, I was also able to make casual examinations of the Pendra Archæans. They, also, agree in many respects with those of Chhindwara, but will receive no further attention in this paper.

Acknowledgments.

Finally I must close this introduction by expressing my thanks to Mr. E. H. Blakesley, Political Agent to the Chhattisgarh Feudatory States, and to Pandit Ghore Lal Pathak, Superintendent of the State, for the very efficient arrangements that were made for my visit.

[1] *Zamindari*-estate.

CHAPTER II.

PHYSICAL ASPECTS AND GENERAL GEOLOGY.

Physical aspects.

This State being so little known and out of the way, I cannot do better than remove bodily from the Gazetteer of the Chhattisgarh Feudatory States the paragraph dealing with its boundaries and physical features. This paragraph is as follows :—

'Korea was a State in the Chotā Nagpur Division of Bengal until 1905 when it was transferred to the Central Provinces. It lies between 22°56 and 23°48′ N. and 81°56′ and 82°47′ E., with an area and population of 1,631[1] sq. miles and 35,113[2] persons respectively. It is bounded on the north by the Rewah State, on the east by the Surguja State, on the south by the Bilāspur District, and on the west by the Chāng Bhakār and Rewah States. This State is virtually nothing but one vast mass of hill ranges, crowding in on one another and covered with dense forests. In the small villages between the hill ranges there is a little cultivation. The country is divided into three distinct steppes ; the first from the plains of Srinagar in Surguja State on the east of the low lands of Patna and Khargawān ; the second from thence to the uplands round Sonhat and the third to the great plateau stretching away to Chāng Bhakār State on the west. The general level of the lower tableland is about 1,800 feet above the sea. The Sonhat plateau has an elevation of 2,477 feet and the maximum elevation of the highest plateau is 3,370 feet, this being the altitude of the Deogarh peak. The Sonhat plateau forms the watershed of streams flowing in three different directions—on the west to the river Gopath, which has its source in one of the ridges of the Deogarh peak, and divides Korea from Chāng Bhakār, on the north-east to the Son, and on the south to the Hasdo, the largest river in the State, which runs nearly north and south into the Bilaspur District and eventually falls into the Mahānadi. Its course is rocky throughout, and there is a fine waterfall at Kirwāhi. Sonhat was until lately the capital of the State, but the Feudatory Chief found it unhealthy and has recently moved to Baikunthpur (some sixteen miles south) and is constructing a new capital there.'

[1] 'This figure which differs from the area shown in the Census Report on 1901 was supplied by the Surveyor-General.'

[2] The population according to the Census of 1911 is 62,107 persons.

The following is a list of the geological formations represented in this State:—

Geological formations.

1. Deccan Trap (intrusive).
2. Gondwana
   (*a*) Supra-Barakars.
   (*b*) Barakars.
   (*c*) Talchirs.
3. Archæan.

The three plateaux or terraces.

A reference to the geological map (Plate 31) will show that in a general way the geology of Korea corresponds with the division into three plateaux or steps as given in the foregoing quotation. The lowest plateau, that of Patna and Khargaon, is largely occupied by the rocks of the Talchir formation, through which the underlying foundations of Archæan granites, gneisses, and schists, appear as several inliers; whilst on it rest two outliers of the Barakar rocks, comprising the Kurasia and Koreagarh coalfields, rising to elevations of 2,917 feet in Bartunga hill (see Plate 21) in the former field and 2,985 feet in Koreagarh. These two coalfields are outliers of the second or Sanhat plateau, the extent of which coincides almost exactly with that of the Barakar rocks forming the northern coalfield, to which the name *Sanhat coalfield* thus seems peculiarly applicable (see p. 150). The elevation of the second plateau is given as 2,477 feet, the height of Sanhat, but places at a lower level, such as Ghutra at an elevation of about 2,000 feet, must also be regarded as lying on this plateau. The third or Deogarh plateau corresponds with the wide spread of Gondwana rocks designated supra-Barakars and regarded by Hughes as of Mahadeva age. Capping Koreagarh and the hill known as Doman Pahar (2,650 feet approx.) about 2 miles south of Kurasia are two patches of these supra-Barakars, which may be regarded as outliers of the third plateau.

CHAPTER III.

THE DECCAN TRAP.

Dolerite dykes.

Traversing the southernmost plateau is a series of roughly parallel easterly to north-easterly dykes of dolerite, mostly confined to the Talchirs but also appearing in the Barakars. These dykes, judging from their mineralogical characteristics, are of Deccan Trap age. They consist principally of augite, plagioclase and magnetite with interstitial, partially devitrified and altered, glass. Some of them are free from olivine, whilst others contain it in abundance. They are usually non-porphyritic, but the Paradol dyke and the Jhimar N. dyke, with its probable continuation, the Bhukbhuki dyke, contain abundant felspar phenocrysts.

Dolerite sill.

Immediately to the north of the Kurasia coalfield and partly overlying it, the map shows a mass of Deccan Trap lava of very irregular shape. This is not composed of superficial flows of basalt or comparatively fine-grained dolerite, as might at first be anticipated, but consists of a large intrusive sill of dolerite, coarsely crystalline in the centre and more finely crystalline in its upper and lower portions, with the actual margins basaltic for 1 to 3 feet. This sill stretches in a general E. N. E. direction for 25 miles within the limits of Korea State, extending 13 miles further in the same direction into Sarguja, judging from the map attached to Hughes' memoir. Judging also from this map it is probable that a large number of the Deccan Trap outliers shown in the Sohagpur field in Rewah State are portions of this same dolerite sill. Its thickness is very variable, the smallest measurement being about 80 feet at a point about $1\frac{1}{4}$ miles north of Nagar (eastern village); the maximum thickness measured was on the hill 2,847 △ west of Kurasia, where an approximate vertical thickness of 350 to 400 feet was measured. The summit dolerite being of the most coarsely crystalline type represents, possibly, the middle of the flow, in which case the sill may have had an approximate thickness of 700 to 800 feet at this point. Judging from the few points at which this sill was visited, it has a general N. N. W. dip; at one point this dip could be definitely measured, namely near Nagar, where it is 22°

to W. 35° N. At this particular point the sill has intruded itself between the topmost layers of the Talchirs almost at the junction with the overlying Barakars. To the E. N. E. of this point the sill seems to be definitely intrusive in the Barakars throughout practically the whole of its course, whilst to the west and south-west the sill rests partly on the Talchirs and partly on the Barakars. It will be noticed from the map that some of the dykes are represented as definitely joined up with this sill and there can be no reasonable doubt that they represent the fissures through which the molten magma ascended. The elevation of the base of the sill where it rests upon the underlying rocks is very variable; thus on the Sanhat Ghat road leading from Baikanthpur to Sanhat, N. E. of Buskata H. S., this height was measured as 2,435 feet. At the point near Nagar above referred to, this base is at only 1,960 feet. On the south slope of Kuro hill (2,496 feet) south of Nagar it is at about 2,350 feet; in the Kurasia nala about 5 miles further south-west the dolerite base is seen at 1,927 feet, quickly rising to about 2,450 or 2,500 feet on Kurasia hill (△2,847); whilst, finally, 5 miles further south-west, I discovered a very small outlier on the top of Bartunga Hill with its base at about 2,900 feet. These differences in elevation are, no doubt, partly due to the effects of denudation upon a dipping bed of rock; but they are undoubtedly partly due to the sill gradually rising or sinking in stratigraphical position.

The main channel of eruption of this sill, judging from Hughes' map, is probably the dyke indicated as stretching at intervals for some 26 miles from Sardih on the east, through Sarola, to a point north of Bouridand on the west. It is interesting to notice that these doleritic dykes are nowhere shown on Hughes' map as piercing the Archæan rocks. This may be due to the fact that Hughes and Hira Lal were chiefly studying the Gondwanas and therefore did not devote any more attention to the Archæan inliers than was necessary to delineate their outlines; or it may have some special meaning not yet discovered. The striking case south of Siroli, where the dyke is shown as stopping short on either side of the Archæan inlier, where the Hasdo river crosses it, lay in my way. Unfortunately heavy storms had flushed the Hasdo into semi-flood and I was able only to investigate the western shore. Here, however, I found the dyke actually extend-

ing into the water, and judging from such outcrops of granitic rocks as protruded above water there was no reason why the dyke should not cross the river and connect up with the dyke-ridge seen clearly on the opposite bank.

As in the case of the dykes, so also in that of the sill, the dolerites are composed of the minerals characteristic of the Deccan Trap surface lavas, namely augite, plagioclase, and magnetite, frequently with interstitial patches of partly devitrified and altered glass. Olivine is present more frequently than not, often in abundance; but, curiously enough, the coarsely crystalline centre of the sill is usually devoid of olivine, as if sufficient time had elapsed after the intrusion of the sill and before its solidification, except at the actual margin, to permit of a degree of magmatic differentiation, in which the olivine crystals or the olivine-forming constituents had migrated from the centre of the sill towards its more peripheral portions. The central dolerite is so coarsely crystalline that it would be termed a gabbro were it not for the ophitic relationships of the augite and plagioclase and also the existence of the devitrified interstitial patches already mentioned. These dolerites are clearly of considerable petrographical and petrological interest, rendering it desirable to defer their detailed treatment to a future occasion: the same course seems necessary with reference to a series of volcanic rocks of uncertain age provisionally designated the Chirmiri volcanic series and to which a brief reference must now be made.

Chirmiri volcanic series.

About a quarter of a mile north-east of the most easterly hamlet of Chirmiri village on the road to Kurasia, there is an outcrop of a curious volcanic rock traceable at intervals in a north-north-westerly and southerly direction for about three quarters of a mile. It is a vesicular rock apparently approximating to an andesite in composition; and from its vesicular nature one would deduce it to be a surface lava. Its linear distribution, however, suggests a dyke, and this supposition agrees with the fact that associated with it are included fragments of Barakar sandstones and shales. There are also admixtures of the two rocks, in which grains of detrital quartz are scattered through an andesitic matrix, whilst in addition there are banded hornstone-like masses of rock suggesting shales indurated by heat. All the facts mentioned above, except the vesicular structure, point to

an intrusive character; but at one point, where a stream cuts across the line of outcrop of these vesicular lavas and associated altered sediments, it is found that these curious rocks do not continue in depth, typical massive Barakar sandstone being at once exposed. The evidence of the stream suggests a superficial distribution for the lavas. This agrees with the vesicular and, sometimes, almost pumiceous character of the lava and conflicts with its linear distribution and the altered character of the immediately associated sediments. In the short time at my disposal, I examined all the evidence that was immediately available, but was unable to reconcile the conflicting evidence with either hypothesis. Under the microscope the rock is seen to show extremely numerous felspar microlites in a colorless to black glassy matrix, often vesicular. In the most coarsely crystalline variety, the laths are found to be labradorite with an extinction of 39° referred to the albite twinning. They are set in a glassy matrix containing skeleton magnetites, but no augite. The rock seems, therefore, to be an unusual variety of *andesite*, corresponding in composition to the groundmass of typical andesites, the ferromagnesian silicates being absent.

On the Kaoria Nala and its tributaries, I found several other obscure occurrences of this series of vesicular lavas and included sediments, usually in the form of loose blocks; but for want of time I was unable to track the fragments to their respective sources and thereby possibly obtain the key to the solution of the problem.

It must be noticed that if we ascribe a superficial origin to these rocks we are confronted with one of two alternatives. Either the lavas were extruded during the course of deposition of the Barakar sandstones at a fairly low horizon in the series, or they were erupted in recent times after denudation had cut down the Barakars to their present level. So far as I am aware there is no evidence of volcanic activity anywhere in India in the whole of the Gondwana period until Rajmahal time, nor does the alternative of a recent age seem in the least degree possible. If we adopt the hypothesis that these rocks, in spite of inconsistencies, are intrusive, then we are provided with a possible source in the volcanic intrusions of Deccan Trap age, of which, as already related, there is abundant evidence in the form of the doleritic sill and dykes. It is true that the Chirmiri rocks are of andesitic not

doleritic composition, but this is not a serious objection, and it may be that the glassy matrix if crystallised would have yielded augite. For the present, therefore, I am inclined to adopt the hypothesis that the Chirmiri volcanic rocks are of intrusive rather than of extrusive origin and possibly of Deccan Trap age, although there is no direct evidence of this. The facts against this hypothesis, namely the vesicular nature of the rock and its failure to extend in depth where the stream cuts across its outcrop, are not insurmountable difficulties, and may be explained at some future period when it is possible to make a careful investigation of this problem.

CHAPTER IV.

THE ARCHÆAN ROCKS.

As will be seen from the geological map, there are numerous inliers of Archæan rocks in this State. A brief account must first be given of the petrographical composition of such of these inliers as it was possible to visit. We will then discuss the relationship of the Korean Archæans to those of the Satpuras further west.

The first inlier to be visited was that of Phunga in the S. W. corner of the State. This hill mass is of very irregular outline, and rises to a height of 1,671 feet. It is entirely composed, as far as I examined it, of a medium-grained hornblende-granite with red felspar. The rock shows no noticeable gneissose structure, but is seen under the microscope to be exceedingly crushed and strained. One leucocratic variety was collected in which the hornblende was small and scarce, the rock itself showing a tendency to gneissose habits.

The Phunga inlier.

The next inlier to be visited was that on which is situated the large village of Khargaon, the headquarters of the *zamindari* of the same name. This mass was traversed from Khargaon in an N. N. W. direction towards Chirmiri. The rocks examined consist of a series of crushed biotitic gneisses, in a general way very similar to those examined in detail by Mr. Fox and myself in the Nakta Nala, Chhindwara district (*Rec.*, *G. S. I.*, XLIII, p. 34, 1913). They vary from an augen-gneiss, through more crushed varieties of the same, analogous to our bead gneisses, to a biotite granulite, and finally to a dark grey quartzite-like rock containing scattered specks of pyrite and found under the microscope to consist largely of an aggregate of quartz and felspar with minute biotite, epidote, and a black ore, probably ilmenite. There seems to be every gradation between a coarse augen-gneiss and this fine-grained pyritic granulite, just as in the Nakta Nala there is every gradation between coarse augen-gneisses through bead-gneisses, necklace-gneisses, and granulites, to hornstone-gneiss, which seems to be an even more intensely crushed rock than any of those of Khargaon. The original ferro-magnesian mineral of this series, as in Chhind-

The Khargaon inlier.

wara, is biotite, but well-formed idiomorphic dodecahedral pink garnets are contained in one specimen of augen-gneiss, garnet being also an occasional mineral in the augen-gneisses of Chhindwara. At the northern end of this inlier I found abundant blocks of a fine-grained biotite-epidiorite, very similar to some of those discovered by Mr. Fox in the Kanhan valley of Chhindwara. I must not omit to state that the dips in the Khargaon inlier, where seen, varied in direction from north-west to south-west, averaging west to south-west, the angle of dip being 30° to 40°.

The Salba inlier.

The next inlier to be visited was that of Salba, rising to 1,785 feet. This was crossed between Mansak and Cher (Chare) on the march to Baikanthpur. On the ascent after crossing the Dharhund nala, one meets a series somewhat similar to that of Khargaon, consisting of crushed porphyritic gneisses (augen-gneiss and bead-gneiss) and granulites, with interbanded, rather fine-grained, richly hornblendic gneiss. The strike is W. N. W., vertical. In the Jhunka Nala between Salba and Cher are seen vertical green schists striking east, and followed by porphyritic biotite-gneiss.

The Patna inlier.

The fourth inlier to be noticed is that on which is situated Patna, the chief village of a zamindari of the same name. The western end of this inlier was visited on the march from Baikanthpur *viâ* Ani to Rakeya. South-east of Ani is a low ridge composed of a siliceo-calcareous series of rocks that must be regarded as metamorphosed sediments and are probably to be correlated with the Dharwars. The rocks vary from a fine-grained quartz-schist containing scattered calcite and a certain amount of biotite, through quartzites extremely rich in calcite, to siliceous fine-grained limestone. There is also a band of diopside-quartz-rock traversed by irregular veins of calcite and quartz, the quartz forming small crystals in druses. A peculiarity of these quartz crystals is that they frequently show

Quartz crystals.

the face *s* ($11\bar{2}1$) which I have only once previously found in India, namely, on the quartz crystals found in druses in quartz veins traversing the Dharwars in the neighbourhood of Chaibassa in Singhbhum. The same face is also present on some of the quartz crystals from the sapphire mines of Kashmir. Some of the Ani quartz crystals show trigonal terminations like those so characteristic of Deccan Trap geodes.

Not very far to the north of this series and still to the south of the present position of Ani village, medium-grained hornblende-granite crops out. To the north of Ani village is an outcrop of leucocratic pink coarse-grained granite with both white and red felspars and subordinate quartz and biotite. The felspar is sometimes in graphic intergrowth with quartz, and the rock suggests the irregularly pegmatitic granite dykes found in the Nakta Nala, Chhindwara. Associated with this granite is a melanocratic epidote-hornblende-gneiss, probably a metamorphosed dolerite. Further north some bedded fine-grained granulites were crossed, followed by a considerable extent of crushed biotite-gneiss. In the Gej Nala, pink bead gneiss and coarse-grained, red, very felspathic gneiss are exposed. The general strike of the rock of this inlier is E. N. E., in places vertical, and in places with a moderate to steep dip to the south.

The Siroli inlier.

The rocks of the Siroli inlier lying at the western end of the State, and traversed by the Hasdo river, consist, as far as examined, of porphyritic biotite-granites, often gneissose, and sometimes converted into augen-gneiss. They are associated with fine-grained grey gneiss with scattered phenocrysts. The strike varies from E. by N. to E. by S.

The Karimati inlier.

The smaller inlier east of Karimati and only some 3 miles S. W. of the Siroli inlier also consists of augen-gneisses, with an E. 10° N. strike.

The pre-Talchir Archæan surface.

On crossing from the Archæan group to the Talchirs, one is often very puzzled as to where the exact boundary should be drawn. This is due to the fact that the Talchirs were deposited on a hilly and extremely irregular surface of Archæan rocks, many of the summits of the Archæan hills now protruding through the Talchirs. This phenomenon is exceedingly well seen in the Phunga Archæan inlier, where small patches of Talchirs, identifiable by the character of the boulders, are found scattered about on the granitic massif. No general elevation, therefore, can be assigned to the Talchir-crystalline boundary, for most of the Archæan inliers stand up as peaks from the shrouding Talchirs which, generally speaking, occupy the lower ground. Compare, for instance, the height of Dewadand, 1,273 feet, with that of Phunga, 1,671 feet. The most marked exception to this state of affairs is the peak known as Churi, which, as seen from

the north, is a beautifully symmetrical pointed cone. I was not able to visit it, but, according to Hughes' map, it consists of a basement of Archæan rocks with a strip of Talchirs climbing up from the low ground to the north to form the summit of the hill and descending again to the south. On an one-inch geological map of this area it would be possible to represent many more small Archæan inliers than are shown on the map appended hereto.

Easterly extension of the Satpuras.

It will be seen that I have been able to match most of the crystalline rocks collected in Korea with more or less similar rocks from the Chhindwara district. Except in the Khargaon inlier, the strikes, which vary from E. N. E. to E. S. E., agree with the idea that the foundations of Korea consist of an east-north-easterly extension of the crystalline core of the Satpura Range; and the dips and strikes, and in many respects the characters, of the rocks observed in the Pendra zamindari to the west of Korea do not conflict with this idea.

This suggestion that the crystalline core of the Satpuras (which we may term the *Satpuran protaxis*) continues as a geological entity as far as Korea, naturally leads one to speculate on how much further to the east this protaxis continues. In the absence of any personal acquaintance with the country east of Korea, I cannot at present discuss the question further, except to suggest that the Ranchi plateau will probably be found to be a portion of the ancient Archæan range of hills, the western portions of which now form the core of the Satpuras.

Age of the Satpura core.

Although we cannot yet draw any decided conclusions as to the age of this Satpuran protaxis, yet some tentative ideas will not be out of place. If there be any connection, as seems probable, between the folding of the gneisses and schists constituting this core and its elevation as a mountain range, of which the core probably forms the denuded remnant, then we cannot accept the suggestion[1] advanced on page 491 of the *Manual of Geology of India* (2nd edition, 1894) that:—

"The close of the Cuddapah epoch appears to have witnessed a commencement of the earliest of those earth movements whose effects on the surface contours and geography of India are still prominently noticeable."

[1] I am indebted to my colleague, Mr. Fox, for drawing my attention to this passage.

After referring to the Aravallis, it is stated :—

"At the same time another zone of contortion was formed running along the south side of the Son and Narbadá valleys, which was probably marked by a range of mountains or hills, not rising to the same height or importance as the Arávallis, and bearing much the same relation to them as the hills west of the Indus alluvial plain do to the Himálayas of the present day."

According to the division instituted by Sir Thomas H. Holland, in favour of which the evidence seems conclusive, the ancient non-fossiliferous rocks of the Peninsula of India may be grouped into two main divisions, the Archæan and Purana, of which the younger Purana rocks have as a rule suffered practically no metamorphism and dip at gentle angles, whilst the Archæan rocks on which they rest have frequently been subjected to intense metamorphism, folded together, and forced to dip at high angles, so that there is a vast unconformity, termed by Holland the great Eparchæan unconformity, between the whole congeries of rock systems grouped under the term Archæan and the systems included under the term Purana. It is difficult, therefore, to accept the suggestion that the formation of the earliest Satpura range is to be ascribed to the close of the Cuddapah period. The gneisses and metamorphosed Dharwar sediments must have suffered their principal folding prior to the Eparchæan interval. In addition to these folded gneisses and schists, an important constituent part of the Satpura core consists of the various unfoliated or but slightly foliated granites so abundant in Chhindwara, Seoni, Mandla, and Balaghat, on the west side of the Maikal range (of which Amarkantak forms one of the highest peaks), and in Pendra and Korea on the east side of this range. There is no reason for regarding these granites as of any but Archæan age, and we may explain their intrusive relations with regard to the associated gneisses and schists, and also their comparative freedom from foliation, on the hypothesis that their intrusion at the close of the Archæan period was the cause of the upheaval of the Satpuras as a mountain range of which we now see the denuded core; or at least that the intrusion of these granites was intimately bound up with the tectonic movements to which the Satpuras owed their elevation.

These ideas are put forward on the supposition that there is an intimate relationship between the folding of the Archæan rocks constituting the present Satpura core and the formation of the Satpuras as a mountain range, this being the idea expressed in the *Manual* as already quoted, the portion to which I take

exception being that which ascribes the contortion to the close of the Cuddapah period. There is, however, another possibility. If it could be shown that the Satpuras do not owe their elevation to the same processes as led to the folding of their constituent gneisses and schists, but to a system of parallel boundary faults at some subsequent period, then one could no longer maintain that the Satpura range was first formed as an orographical feature in Archæan times. It might then have owed its upheaval to any of the principal systems of earth movements by which the Peninsula has been affected since Archæan times.[1] Should the latter alternative prove to be the true one, evidence in favour of it will probably be obtained in the course of the geological survey now being carried out in the Central Provinces. I put forward these advance speculations concerning the possible mode of formation and age of the Satpuras, firstly because they seem naturally to arise from the discovery of the great similarity, both petrographical and structural, between the Archæan rocks of Pendra and Korea and those of Chhindwara, and secondly in order to indicate what seems to me to be the present state of the problem.

[1] The idea advanced in another paper, on the physical activity of the Hasdo River, that at the beginning of Talchir times there was already a breach in the Satpuran protaxis where Korea now lies, sets, if correct, an upper limit to the age of this range.

CHAPTER V.

THE TALCHIRS.

Distribution.

As has already been stated, the principal portion of the southernmost or Khargaon plateau of Korea State is occupied by the Talchir formation. In a general way these Talchirs agree with the typical Talchirs of the country further to the east, being composed largely of shales, usually greenish or blackish, but sometimes dull purplish, with or without scattered boulders and pebbles. Interbanded with these Talchir shales there are frequently thin courses, averaging 3″ to 1′ thick, of a very fine-grained limestone (see Plate 22, fig. 1). There are also ovoid masses of similar limestone up to a yard long, which are almost certainly of secondary origin, probably formed by concretionary action accompanied by replacement of the shale. These limestones are well seen where the track from Jaraunda to Phunga crosses the Budra Nala. Some of the shales at this point are traversed by an intricate network of thin veins of calcite evidently of secondary origin. Traversing the black shale there are also seams of fibrous calcite up to an inch thick, whilst an immediately adjoining band of limestone contains dull black remains of shale pointing to the formation of the limestone by replacement of the shale.

Lithology.

Throughout the series there seems to be a great abundance of boulder beds in which the matrix is usually shaly, but not infrequently very sandy. The pebbles and boulders are composed of a great variety of materials some obviously local and some exotic. The local boulders consist, of course, chiefly of various gneisses and granites, and in some places near the junction between the Talchirs and the underlying Archæans, blocks of some particular variety of gneiss or granite become so large and numerous that it is difficult to determine whether one is looking at the actual summit of a buried Archæan peak, or at loose blocks of the Archæan rock shifted only a small distance before being incorporated in the Talchirs. The fragments that are obviously of exotic origin are not usually larger than 1 foot in diameter, and are frequently quite small pebbles. Amongst the foreign materials are varieties of quartzites, a certain proportion of pebbles obviously derived

from the Vindhyan formation, and occasional pebbles or small boulders of red jasper breccia that might have come from the Bijawars. Amongst the Vindhyan fragments some were indistinguishable, as far as memory went, from the Upper Rewah sandstone that I had seen in Baraunda State in Central India immediately before my visit to Korea. Other pebbles might have been derived from the Kaimurs. Vindhyan fragments seemed most abundant down the western margin of the State, and were particularly common near Sakra in the S. W. corner. Some of the largest masses were angular blocks, whilst others were well rounded boulders and pebbles. Many of the small boulders and pebbles in the Talchirs show the facetting characteristic of the group and occasional scratched pebbles are found, the scratches being best preserved on hard fine-grained materials (see Plate 22\ for a fine example of a scratched and facetted boulder). Since the nearest Upper Vindhyan rocks lie in Central India to the north and north-west, where Bijawar rocks also occur, it seems likely that the ice concerned in the formation of these boulder beds came from the N. W. quadrant. In another paper it is suggested that Korea marks the position of a breach in the Satpuran protaxis, through which flowed the river that deposited the line of Gondwana rocks stretching through Sambalpur to Talcher State.

Towards the upper portion of this series, sandstones occur in considerable abundance; they are usually extremely fine-grained, frequently argillaceous and of some tint of greenish to brownish-yellow. Not infrequently, however, they are comparatively free from argillaceous or ferruginous material, and are then harder and of pale cream tints.

Character of Barakar-Talchir boundary.

The only place where I saw a good exposure of the actual boundary between the Talchirs and the overlying Barakars was in the Gorghela Nala, north of Dubchola. The exposures here are practically continuous, indicating a gradual upward passage from Talchirs to Barakars. The uppermost Talchir rocks form an interbedded series of shales and fine-grained argillaceous sandstones, with some thin bands of limestone, and a little sandstone with poikilitic calcite cement; whilst the lowermost Barakars consist of predominant fine-grained argillaceous sandstone with occasional interlaminated shaly bands, passing upwards into coarser grained

felspathic sandstone and downwards into the still more fine-grained uppermost sandstones of the Talchirs. The exact point at which the boundary should be drawn is a matter of personal preference. Attention may here be drawn to the statement at the bottom of p. 161 of the *Manual of the Geology of India*, where, with reference to the Karharbari stage, the following passage occurs :—

'It is probable that this group will be found to have a wider distribution than is now known and to be represented in all those sections where the Talchirs are described as conformable to the beds above them.'

No fossils were, however, found in the section: but this does not prove their absence, and it is possible that a careful search in the series of thin coal seams forming horizon No. 1 (see page 180) in the Barakars, only some 40–50 feet above the approximate Talchir-Barakar boundary, might lead to the discovery of fossil plant remains well enough preserved to determine whether or not the Karharbari stage is present.

Thickness of the Talchirs.

As has been related in the previous chapter, the Talchirs fill up all the hollows in the pre-Talchir Archæan surface, lapping round the higher Archæan summits, which now appear as inliers in the Talchirs and were no doubt previously covered to a considerable extent by Talchirs, since denuded away. The deposition of detritus in a lake by melting ice seems a peculiarly simple method of filling in the depressions and gradually covering all the lower hills of an irregular Archæan surface. Consequently we must expect to find great differences in the elevation of this formation from point to point according to the elevation of the underlying Archæan surface at each spot. The lowest levels at which the Talchirs occur in Korea are near its southern boundary, the lowest point marked on the map being 1,273 feet near Dewadand, so that where the Hasdo river actually leaves the State the Talchirs there exposed cannot be at an elevation of much over 1,200 feet. Along the northern edge of the Talchirs the following approximate heights were determined :—

Gej Nala near Rakeya	1,900 feet.
E. of Balbahara	1,678 ,,

The height of Churi Hill is not stated on the map, but it must be well over 2,000 feet, probably at least 2,200, which would give a vertical distance of 1,000 feet between the highest and lowest portions of the Talchirs, supposing they had suffered no dis-

turbance since deposition: but this would not be the true thickness of Talchirs at any one point. I have no exact data by which to estimate this, but I should be surprised if it anywhere exceeds 500 feet.

Dips in the Talchirs.

The Talchirs, however, are by no means still in their original positions; for although in places they may be approximately horizontal, yet where a good section is observed they usually show a small dip (up to 10°) in a northerly direction (varying between north-west and north-east). Locally the dips may be much higher; thus, in the Budra N. near Phunga the calcareous rocks already referred to in the beginning of this section show dips varying from 30° to 60° to N. 35° E., although the general dip of the shales just here is very small. In a small nala N. E. of Nagar the Talchirs immediately overlying the dolerite sill show a dip of 20°—25° to W. 35° N., whilst in the Gej Nala between Rakeya and Murma, pebbly beds dip at about 40° to N. 40° E. At this particular point the high dip is probably connected with local disturbance, for, a little further upstream at about the junction between the Barakars and the Talchirs, Talchir shales are seen thrown into several small sharp folds,- no less than six in the course of six yards. These folded shales abut abruptly against sandy shales, there being almost certainly a small north-westerly strike fault in the Talchirs at this point.

CHAPTER VI.

THE BARAKARS.

Distribution.

Resting on the Talchirs come the Barakars, of which, as will be seen by a reference to the map, there are four separate patches within the limits of the State.

The most northerly of these, which is also by far the largest, stretches right across the State from boundary to boundary with a maximum length of about 50 miles in an E. by S. direction and a width of 8 to 12 miles at right angles to the strike, which averages E. by N. This patch corresponds approximately with the second of the table-lands mentioned on p. 154, and is the eastern extension of the Sohagpur coalfield, continuing to the E. into the Jhilmili zamindari of Sarguja State, where it joins on to another coalfield known as the Jhilmili coalfield. For this northern strip of Barakars, I have suggested the name Sanhat coalfield (see p. 150); its total area is about 330 sq. miles and its highest point, Chamat Hill, 2,797 feet.

To the west of the Hasdo river, on the western border of the State, is a small projection from the Sohagpur field occupying only 22 sq. miles. Coal is known to occur in the Jhagrakhand, Kulharia and Neori *nalas*, but the total area is so small that it seems unnecessary to give it a separate name.

The third patch of Barakars is the Kurasia coalfield, an outlier of some 48 sq. miles in area, and reaching its highest elevation at Bartunga Hill (2,917 feet) of which the upper 10—15 feet consist of dolerite.

The fourth and last patch of Barakars is the Koreagarh field, an outlier 6 sq. miles in area reaching an elevation of 2,985 feet at Koreagarh and 2,494 in Dugi Dei, each hill being capped by Supra-Barakars.

Dips in the Barakars.

The greater portion of my visit was devoted to the Kurasia coalfield, but I also travelled along the southern edge of the Sanhat field from Murma on the east to Ghutra and Balbahara on the west. As far as I observed, on the southern edge of the Kurasia field the Barakar-Talchir boundary is found at an elevation varying from 1,600

to 1,780 feet. I did not happen to cross the boundary of this field at either its eastern or western end. The height of the Barakar-Talchir boundary on the southern edge of the Sanhat field varies, as far as my observations go, from about 1,850 feet near Rakeya on the east through 2,000–2,150 (Kuro—Hill) feet in the neighbourhood of Nagar in the middle, to only 1,640 feet near Balbahara on the west. On the average, therefore, it is only a little higher than the southern boundary of the Kurasia field. Since almost everywhere along the southern boundary of the Sanhat field, there is a marked northerly dip ranging between 6° and 20°, and averaging about 10° to 12°, it is obvious that if this dip had continued to the south in those portions of the Barakars that once joined the Sanhat to the Kurasia coal-field, the Kurasia field would have been at a much higher level than it actually is. The rocks of the Kurasia field are, as a rule, approximately horizontal with local dips in various directions due to slight rolling; but taking the accumulation of evidence provided by the numerous dips recorded, there is evidently a slight tendency towards a southerly to south-westerly dip. The evidence, therefore, of the respective elevations of the bases of the two coalfields and the general direction of dip indicate the former existence of a gentle *anticlinal fold*, the axis of which probably lay in those portions of the Barakars, now removed by denudation, that formerly joined the two coalfields.

A reference to the geological map brings out a most interesting point, namely, that the largest exposed spreads of the dolerite sill already discussed on p. 156 lie in this very gap between the two fields, whilst the line half way between the two fields, which is approximately the position where one would feel inclined to place the anticlinal axis already referred to, happens to be occupied by the dolerite dyke indicated on p. 158 as the probable fissure up which rose the lava forming the intrusive sill. It seems, therefore, a reasonable suggestion that the intrusion of these dolerites was the cause of the folding of the Barakars. If this deduction be correct, then we must regard this doleritic intrusion as the principal cause of disturbance in the coalfields of this State. Consequently, when in the future these coalfields come to be worked, as they must be sooner or later, it will be a point of practical importance to the miner to make an exact study of the relationship of the dolerites to the Gondwanas, as thereby he may

be able to trace the connection between such faults in the Barakars as can be directly observed and the presence or the proximity of intrusive dolerite. He will then gradually discover to what distances from intrusive dolerite, either dyke or sill, he is to expect faulting in his coal seams, even where the surface evidence gives no clue.

Faulting.

In the course of my short examination of the Kurasia field I found only one fault actually exposed. This was in the Kurasia nala, N. N. W. of Kurasia, at a point only about 1 furlong south of the main mass of intrusive dolerite (see Plate 23, fig. 1). There is good evidence for the existence of another fault, the direction of which could not be ascertained, in a tributary of the Kaoria Nala, the Gae-mara Nala and also in its tributary at a point about a mile south of a broad dolerite dyke; there is also evidence of the existence in the same neighbourhood of the Chirmiri volcanic series, which must be regarded, in view of its observed effects at Chirmiri itself, as another possible factor in the disturbance of the Barakars.

Lateral movements.

In several exposures, both in the Kurasia and Sanhat fields, where sandstones rest upon coal, I have found evidence of a lateral movement of the sandstone relative to the underlying coal, which is frequently gently crumpled at its upper surface. In one or two places, moreover, this lateral movement has been sufficiently powerful to squeeze out a coal seam entirely, or to pinch it into small lenticles between which the overlying and underlying sandstone come into contact. This is particularly well seen in a rock fall in the Kachhan Kundi, a tributary of the Kaoria Nala, and is illustrated in Pl. 23, fig. 2. At this point not only has the coal been squeezed into lenticles, but the coarse overlying felspathic sandstone contains irregular lenticular strings of the bright coal substance so commonly found not only in the coalfields of this State, but also in the coals from other parts of India, where it is interlaminated with a duller and less pure coal. I can think of no method by which these coal stringers, which are evidently secondary with reference to the sandstone, could have reached their present position except a process of distillation from the coal and condensation in the overlying sandstone of the particular hydrocarbon compounds essential to the formation of this bright coal which must be regarded as the approximately pure coal sub-

stance. The following is a proximate analysis of some material picked from these stringers :—

Moisture	11·55
Volatile matter	34·53
Fixed Carbon	47·50
Ash	6·42
TOTAL .	100·00

The heat required for this suggested distillation of coaly matter must have been developed by the earth movements that crushed the coal. Taking into consideration all the evidence, it is clear that when a series of rocks of such variable characteristics as massive sandstone with interlaminated horizons of coal and associated shales suffers tectonic disturbance, there is a tendency for the massive sandstone to slide over the underlying coal seam with gentle crumpling of the uppermost 3″ to 6″ of coal in mild cases, but with actual squeezing out into lenticles of the whole of a thin coal seam in the more violent cases. In fact the sandstone slides for at least a small distance over the coal with a production of an interbedded overthrust fault.

Sandstone-dyke.

At Lachman Jharia (No. 9, Kurasia field) there is a 'sandstone-dyke' 3 to 5 inches wide, traversing the coal seam vertically in a N. 5° W. direction swerving to N. N. W. The sandstone is a grey and yellow micaceous argillaceous variety, and is probably an infilling from above of a fissure opened in the coal by earth movement.

Contorted sandstone veins.

An allied phenomenon is seen at the Diwan Dham exposure, Charcha (No. 3 Sanhat field). A few inches below the top of the coal is a thin seam of cream-coloured clay, up to an inch thick, absent in places and gradually cutting across the coal, so that at one end it is only 2 inches below the top of the coal, whilst at the other end it is one foot below. There are also three curious contorted sandstone veins running downwards through the coal, two of them starting from the clay seam and one from the overlying sandstone. The coal is slightly disturbed on their edges and broken fragments are enclosed in the veins. One inch from the edge of these veins the coal is quite undisturbed. There is also an irregular patch (5½″ long) of sandstone, starting from the overlying sandstone. This and one of the con-

torted veins is shown in Pl. 24, fig. 2. The veins probably indicate fissures in the coal, produced by some earth movement and filled in by material broken from the overlying sandstone. The patch may be of similar origin, but it is difficult to picture to oneself the actual *modus operandi* of its formation.

Lithological characters and peculiarities of the Barakar sandstones.

Lithologically, by far the greater proportion, probably at least 95 per cent., of the Barakar series consists of felspathic sandstones, in which the *felspar* is white and decomposed. The typical variety is porous, friable, coarse-grained, massive, usually false-bedded, and of a light grey to cream colour. In addition to the *quartz* and felspar, the rock also contains scales of *muscovite*, though these are usually scarce and sometimes, also, minute dark grains, which, judging from the black sand sometimes found, consist mainly of *magnetite*, though some particles suggest decomposed *biotite*. In these black sand there is also an abundance of grains of pink *garnet*, which must, therefore, also occur in the sandstone, at least in places.

This sandstone weathers with a rough, light-grey, rounded surface, on which any structures, such as false-bedding, are excellently picked out. At many localities, especially in the neighbourhood of Chirmiri, the weathered surface has a tesselated appearance, exactly like that seen in sun-dried muds in river-beds, and in spite of the arenaceous character of the rock it seems difficult to avoid the conclusion that this network of cracks represents *sun-cracks* (Plate 25, fig. 1).

At other places the surface of the sandstone is traversed by a network of thin raised ridges, a fraction of an inch to an inch high. They are doubtless due to slight cementation of the sandstone along certain lines, but I could not detect any lithological difference.

In many places the sandstone contains *ferruginous* additions. These usually take the form of spherical concretions from ½ to 2 inches in diameter, but sometimes up to 6 inches across. Frequently they weather out and lie loose in large numbers at the surface. When one of these is fractured it is found to consist of a harder outer shell of limonite or ochre-cemented sandstone with an inner core of softer un-impregnated sandstone. One of these concretions (at the Karauli Dhar coal exposure, in the overlying sandstone) was cemented centrally by pyrite. Where still in

their matrix these concretions either stand up as numerous spheres on the weathered surfaces, or, if weathering has broken through the outer crust, especially of the larger concretions, they give rise to small circular hollows, whence the unaltered core has been removed, surrounded by a ferruginous rim. In addition to these concretions, infiltration of iron oxides may give rise to the formation of irregular hard veinlets, horizontal seams, and coatings along joints, of iron-oxide-cemented sandstone. Further, in some places, whole beds of sandstones are ferruginous, apparently due to the deposition of secondary ochres and limonite.

There are frequent variations in the texture of the sandstones, which are sometimes coarse grits full of rounded, sub-angular, or angular fragments of quartz, with fewer fragments of felspar. Thin beds are also found composed largely of large fragments of white decomposed felspar $\frac{1}{4}$ to $\frac{3}{4}$ inch in diameter. *Pebble beds* also occur here and there, and, although they are not of any thickness, they make their presence evident by disintegrating into large numbers of small rounded pebbles, usually $\frac{1}{2}$ to 1 inch across, scattered over the surface.

As on the banks, so in the rivers and stream-beds the sandstones usually exhibit a rough, grey surface, with the false-bedding, and ferruginous concretions and plates weathering out; but in addition the running water has frequently carved out an extraordinary number of *pot-holes* from a few inches up to several yards across (Plate 25, fig. 2).

Sandstones underlying and overlying the coal series.

At irregular intervals in the vertical succession these coarse-grained sandstones contain intercalated beds of coal, shale, and finer-grained sandstones in great variety. Each of these associations may be termed a *coal series* or *coal horizon.* The sandstones immediately *underlying* each coal series are more argillaceous and finer-grained than the generality of Barakar sandstones, being also less massive, and indeed often flaggy and well bedded, occasionally showing ripple marks. They also frequently possess a greenish or yellowish tint due to ferruginous or argillaceous matter. Their deposition seems to indicate a slight deepening of the water preparatory to the laying down of the coal series itself.

The sandstones immediately *overlying* each coal series are often typical coarse varieties, indicating a rapid shallowing of the water after the deposition of the coal. They sometimes contain detrital

laminæ and fragments of shale or of coaly matter, indicating the lapse of a slight interval between the deposition of the coal series (? in lagoons) and the resumption of the shallow fluviatile conditions under which the typical false-bedded sandstones must have been deposited.

In the discussion of the Talchirs (page 168) it has already been pointed out that fine-grained argillaceous sandstones also occur at the base of the Barakar series. In fact the Barakar period seems to have commenced with a gradual shallowing of the deeper waters of the Talchir (? lacustrine), leading to their conversion into river valleys.

The coal series.

The rocks comprising the coal series or coal horizons are :—

(1) coal ;
(2) every intermediate stage between coal and carbonaceous shale ;
(3) several varieties of shale comparatively free from carbonaceous matter, and often very micaceous ;
(4) shaly sandstones or sandy shales composed of alternating layers of shale—carbonaceous or micaceous—and fine-grained sandstone, usually very micaceous, and with the various layers thinning out lenticularly or displaying false-bedding on a small scale ;
(5) micaceous sandstones, usually well-bedded or flaggy.

The coal often occurs as the topmost stratum, resting either on shale or shaly sandstone, the latter passing down into the flaggy micaceous sandstone. But there is sometimes a small thickness of shale overlying the coal. In places the coal occurs alone, overlain and underlain directly by sandstone, being then usually very thin. When more than one coal seam occurs in a section there may be a great number of alternations of carbonaceous, argillaceous, and arenaceous rocks. Further, the coal seams themselves are frequently broken up by shaly or sandy partings. The total thickness of rocks in these coal horizons is very variable, sometimes only a few feet, more usually 10 to 20 feet, but sometimes very much greater, the greatest thickness observed being at the Karar Khoh in the Kaoria Nala (Kurasia field), namely about 92 feet (see page 205). The associated shales and sandstones are usually more important in the Kurasia field than in the Sanhat field, there being also a tendency for a greater thickness of coal at one horizon. A good idea of the composition of these coal

horizons can be obtained by glancing through Appendix I. The characters of the coals will be dealt with in a separate section.

Mode of outcrop of sandstones.

The ordinary sandstones of the Barakar series are not only very massive, but also as a rule remarkably free from joints, except master joint planes that extend vertically for considerable distances (see Plate 24, fig. 1). The coals and shales of the coal series, on the other hand, are not only well-bedded, but are broken up by a great abundance of joints in intersecting series. These differences, as well as the different hardnesses of the respective rocks, lead to very striking contrasts in the modes of outcrop. Since they afford but little soil, the massive sandstones crop out at the surface almost everywhere on the hill-slopes and in the stream-beds. They also give rise to magnificent vertical cliffs, which are seen to the best advantage on the southern edge of the Kurasia field, the southern face of Bartunga Hill being especially noteworthy (see Plate 26). The *nalas* or water-courses being often of steep gradient, are adorned with a succession of rock-falls and waterfalls over barriers of sandstone.

Mode of outcrop of coal seams.

The coal and shale, on the other hand, on account of their softness compared with that of the massive sandstone, are never found exposed on the hill-slopes, being covered either by soil or by sandstone detritus derived from the overlying sandstone cliffs; their outcrops are confined to the ravines and water-courses. There are three chief modes of occurrence of coal seams.

Coal outcrops in cliffs and ravines.

The coal may crop out at the foot of a sandstone cliff (sometimes as much as 80 to 100 feet high), forming the head of a stream, as is well seen in numerous ravines around Bartunga Hill; in these cases the coal is sometimes clearly exposed and sometimes partly or entirely hidden by dèbris from the sandstone cliffs, there being insufficient water, except perhaps in the rainy season, to remove dèbris. The coal series usually projects from beneath the sandstone, forming a succession of steps down the ravine, often partly hidden by boulders and jungle; but the coal itself is sometimes undercut. There is usually a small spring dripping over the rocks.

Coal outcrops in water-falls or "ghāgs."

Secondly, the coal seam may crop out at the foot of a sandstone fall across a river or watercourse. The coal seam is usually undercut beneath the

sandstone, so that the latter forms an overhanging cliff or barrier (see Plate 27, fig. 2); in places the coal series is eroded far enough backwards to give rise to a cave, in which the coal itself forms a part of the walls whilst loose blocks of sandstone fallen from the roof often litter the floor. In one case (Biyah Mandha Nala—Sanhat, No. 14) the erosion of the coal has given rise to a flat cave some 3 to 5 feet high extending inwards for 60 yards, where there is a small inlet from the bed of the dry water-course above, part of the water in the rains evidently passing over the fall, and a smaller portion through the cave itself. In the smaller stream-beds there is as a rule no water in the dry season, but in the larger streams and rivers there is every gradation from a mere trickle over the edge of the fall, to a fine waterfall. These falls, whether dry or provided with water, are locally known as *ghāg*, the finest I saw, and I believe the finest in the State, being the Kirwahi Ghag on the Hasdo River figured in Plate 28. The height of the fall is about 75 feet, and the river here has eroded in the sandstone and underlying coal series a magnificent cirque some 200 yards across.

In prospecting for coal, therefore, it is necessary to examine the base of each of these ghags or barriers, coal being often found where not otherwise indicated by peering between the sandstone blocks that sometimes litter the base of these falls.

Ferns, stalactites, etc.

As might be anticipated, both the deep ravines noticed earlier, and these ghags, are often profusely adorned with moisture-and-shade-loving plants, such as ferns, mosses, and liverworts. Indeed, nowhere in India, not even in the moist parts of Sikkim, nor in the Nilgiris, have I noticed a greater variety of ferns, and a botanist would probably be amply rewarded by a visit to the coal terrains of this part of India. Stalactites, also,—though always of small size (up to 6 inches long)—are not infrequent in the under-cut caves.

As would be expected in a part inhabited by aboriginal tribes (Bhuinhars, Gonds, etc.), to whom most of the secrets of the jungles are known, each of these ghags and caves has a distinctive name, derived, usually, from some physical feature or tradition; this name is frequently extended to the stream itself, or to a section of it until another barrier or some other natural feature leads to a change of designation.

Coal outcrops in gentle streams.

The third mode of occurrence of the coal seams is in streams of low gradient, frequently largely alluvial, as in the Dhuneti Nala near Ghutra. In such a case the coal seam, usually with gentle dip, may form a small outcrop projecting above water or sand, or may extend as a flat outcrop for many yards.

Number and thickness of coal seams in one horizon.

Now let us consider the coal seams themselves. Those occurring in a given horizon may be either single or two or more in number, separated one from another by one or more of the rocks enumerated on page 177. They may vary in thickness from an inch up to some 12 feet. As examples of a single thin seam mention may be made of the 9 inch seam of Biyah Mandha Nala (Sanhat field, No. 4), and a 4 inch seam in the Chirra Jharia (Kurasia, No. 10); whilst as examples of a single thick seam mention may be made of the Bijaura Jharia (Kurasia, No. 7) 9 foot (? 15 feet) seam, the Gorghela Nala 8 foot seam (Kurasia, No. 4), and the Balbahara 10 foot seam (Sanhat, No. 18). For the extremes amongst multiple seams we may notice the lowest horizon in Gorghela Nala (Kurasia, No. 1), where 9 seams totalling only 30 inches occupy a total thickness of 23 feet 8 inches and the Karar Khoh section in the Kaoria Nala (Kurasia, No. 33), where 7 seams totalling 36 feet occupy a total thickness of 47 feet.

Characters of the coal.

We may now notice the characters of the coal. It is of the typical Gondwana banded habit, consisting of various proportions of bright and comparatively dull coal. The *bright coal* is the purest, and, judging from its brilliant conchoidal fracture, is of the nature of a colloidal substance which has in some way segregated chemically from the admixed earthy materials that give rise to the greater proportion of the ash of the coal. This is well illustrated by the proximate analysis of a picked pure material from Daukihuri (Kurasia, No. 6) given below in Table No. 1.

This bright material usually occurs in bands from $\frac{1}{8}$ to $\frac{1}{2}$ inch thick, but is sometimes 1 or even 2 inches thick. It is very brittle, falling to pieces readily; it usually alternates with the dull coal, but bands are occasionally found consisting entirely of bright coal up to a thickness of 6 inches. One variety, rather rare, consists of very thin alternating bright and dull laminæ, the coal having a general bright appearance. A specimen of such coal from Balbahara showed a specific gravity of 1·51, whilst a piece

from horizon 1, Gorghela Nala, showed a specific gravity of 1·52, and had the laminæ so fine as to look at first sight like entirely bright coal (see table 1 for analysis).

The *dull coal* can only be so called by comparison with the bright coal. It really has a distinct lustre varying from greasy to silky, and often shows as low a specific gravity as bright coal. Thus a dull greasy-looking shaly coal from Kachhan Kundi Nala has a specific gravity as low as 1·36. As will be seen from the analysis in table 1, such coal is of high quality. Specimens of banded bright and dull coal from seams 1 and 2, Karar Khoh (Kaoria Nala), show G=1·35 and 1·38 respectively.

The dull coal tends to possess a shaly structure, and seems to gradate (see analysis of K. 3, table 1, for an intermediate stage) into a stony coal-shale or *shale-coal* of very distinctive appearance. This is heavy (G=1·64), with a grey-black colour, almost bluish in the sun, a greasy lustre and a conchoidal fracture; the general appearance is that shown by some varieties of psilomelane, except for the fact that this shale-coal is commonly thickly besprinkled with fragments of carbonised vegetable matter, and that it often shows small stringers and veinlets of bright coal. It tends to fracture into slabby pieces, but the shaly structure is not well developed. I refer to it, however, as shale-coal in this report. Its composition is well shown by the analysis of D. 154 in table 1.

In addition, any of the varieties of coal may show films of 'mineral charcoal' or 'mother-of-coal.'

The coal seams are composed of these varieties of coal in different proportions at different localities. Moreover there seems to be every gradation from the dull oal into carbonaceous shale, so that where the partings between coal seams are of a highly carbonaceous nature, it becomes a matter of personal preference whether the two seams should be grouped as one or kept separate. My tendency has been to separate them, but I have followed no rule in this matter, except that of convenience.

Composition of the coal.

The results of the assay of samples of Korean coal taken by me are scattered through the following pages. But it is instructive to give here a summary of results for purposes of comparison. For this purpose the mean composition of each group of samples seems the most suitable :—

TABLE 1.

Analyses of hand-specimens of coal.

LOCALITY.	D. 183. DAUKIHURI.	D. 164. KACHHAN KUNDI.	K. 3. KARAR KHOH, 13″ PARTING BETWEEN SEAMS 3 and 3A.	GORGHELA N. HORIZON 1.	D. 154. PARTING TO SEAM 3, KARAR KHOH.	K. 2. KARAR KHOH. (SAME AS D. 154).	K. 4. KARAR KHOH. SEAM 4.
Character of coal.	Bright coal layers.	Dull slightly silky coal.	Dull silky coal.	Finmly banded bright and dull coal.	Greasy-lustred shale-coal.	Same as D. 154.	Typical dull shale-coal.
Specific gravity . .	1·30	1·36	1·45	1·525	1·64	1·61	1·47
Moisture	9·80	4·66	6·16	4·10	4·10	3·80	4·74
Volatile matter . .	29·18	33·64	27·76	31·52	19·10	22·28	19·90
Fixed carbon . . .	60·51	52·42	49·66	45·84	43·52	38·96	43·30
Ash	0·51	9·28	16·42	18·54	33·28	34·96	32·06
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Caking properties.	Does not cake, but sinters slightly.	Does not cake.	Does not cake.	Does not cake, but sinters slightly.	Does not cake.	Does not cake.	Does not cake.
Colour of ash.	Buff.	White.	Light brown.	Very light grey.	Brown.	Very light brown.	Light brown.

TABLE 2.

Average Composition of Korean Coals.

—	SANHAT FIELD.			KURASIA FIELD.							
				KURASIA AREA.					CHIRMIRI AREA.		
HORIZON.	1	2	Western outcrop.	1	2	3	4	5	3	3 Karar Khoh average.	5
Number of Analyses	3	5	4	1	2	6	6	1	9	10	3
Moisture . .	5·79	4·19	3·48	4·73	5·57	6·19	8·66	10·02	9·46	7·7	7·44
Volatile matter .	22·22	24·00	18·51	29·25	27·18	29·39	30·92	31·06	30·72	29·1	28·22
Fixed Carbon .	44·80	44·00	46·84	45·88	56·21	51·08	48·86	45·64	46·67	51·2	41·65
Ash . . .	21·19	27·81	31·17	20·14	11·04	13·34	11·56	13·28	13·15	12·0	22·69

Striking an average of these figures we get the following mean composition for the Sanhat and Kurasia fields respectively with which are compared average figures for coals from the Raniganj field [1] :—

TABLE 3.

Comparison of Composition of Korean and Raniganj Coals.

—	Sanhat field.	Kurasia field.	Raniganj upper seams.	Raniganj lower seams.	Barakar seams.
Moisture . . .	4·49	7·47	6·81	3·76	1·06
Volatile matter . .	23·58	29·48	32·19	31·51	25·96
Fixed carbon . . .	45·21	48·40	44·76	49·68	56·22
Ash	26·72	14·65	16·24	15·05	16·76
Calorific value (calculated)[2]	5,674	6,217	5,870	6,417	6,915

[1] Ball & Simpson, *Mem., G. S. I.*, XLI, p. 48 (1913).
[2] Goutal., *Comptes Rendus*, Vol. 135, 1902, p. 447, and Cox, *Philippine Journ. Sci.*, A., Vol. 4, 1910, p. 172.

A study of these figures leads to interesting conclusions. In the first place it is noticeable that the Sanhat coals are generally much inferior to the Kurasia coals, the Sanhat coals being much higher in ash, and lower in fixed carbon and volatile matter than the Kurasia coals; it is, indeed, evident on the basis of these figures that attention should first be directed to the Kurasia field. A comparison of the Kurasia analyses with those of coals from the Raniganj measures of the Raniganj field, as given in the foregoing table, indicates the close resemblance between the coals of these two fields. Except that they show higher moisture, the Kurasia coals of seams 3 and 4 are very close in composition to that of the lower seams of the Raniganj series, but are about 2 per cent. better in ash.

A glance at the average analyses of horizons 1 to 5 of the Kurasia section of the Kurasia field reveals another interesting point. The amount of moisture decreases steadily from 10 to under 5 per cent. in passing from horizon 5 to horizon 1. This decrease may be compared with the decrease from 6·8 to 1·06 per cent. in passing from the upper Raniganj seams to the Barakar seams in the Raniganj field (see above). It is also interesting to notice that the Sanhat coals, which occur near the base of the field, contain the same general percentage of moisture as horizons 1 and 2 in the Kurasia field.

Caking properties.

According to the laboratory tests, almost all the Korean coals are non-caking, so that this coal cannot be regarded as suitable for metallurgical purposes.

Sulphur.

Pyrite is often seen in the Korean coals, especially in the seams of bright coal. The only determinations of sulphur hitherto made are as follows:—

Sample K. 9—Seam 3A —Kaoria Nala	0·70% S
K. 13—Seam 5—Kaoria Nala	0·28% S
K. 33—Upper seam—Bijaura Jharia . . .	0·62% S
K. 35—Lower seam—Bijaura Jharia . . .	0·79% S

Calorific value.

No tests have yet been made of the calorific values. But using Goutal's formula, one can deduce from the average composition given on page 183 a calorific value of 6,217 calories for the average coal of the Kurasia field and 6,512 calories for the average of the Karar Khoh seams. These values compare favourably with those for Bengal coals. The Sanhat average gives a much lower value, namely 5,674.

Comparison of Barkui and Korean coals.

For comparison with the Korean coals it will be interesting at this point to give some hitherto unpublished analytical figures relating to the coals of Barkui in the Pench Valley field, Chhindwara district. The first column shows the composition of a large average sample of coal from Barkui. The second and third columns show separately the composition of the bright and dull material constituting the alternating layers of coal. These two analyses were made on small quantities of carefully picked material. The analysis and specific gravity of the bright coal should be compared with the figures for D. 183 in table 1 and the analysis and specific gravity of the dull coal with those of D. 154, K. 2 and K. 4 in the same table. The Barkui coal compared with the average coal of the Kurasia field is higher in fixed carbon and ash and lower in moisture and volatile matter. The figures are as follows :—

TABLE 4.

Analyses of Barkui Coal.

—	LARGE SAMPLE.	PICKED MATERIAL.	
	Banded bright and dull coal.	Bright layers.	Dull layers.
Moisture	1·73	2·20	1·20
Volatile matter . . .	24·07	26·38	19·23
Fixed carbon . . .	52·59	69·56	45·31
Ash	21·61	1·86	34·26
Specific gravity . . .	..	1·295	1·44
Calorific power . . .	7,315	8,690	6,270
Sulphur	0·73%	..	..
Evaporative power . .	13·62	16·18	11·68
Caking properties . . .	Cakes strongly .	Cakes but not strongly .	Does not cake but sinters slightly.
Colour of ash . . .	Light brown .	Brown .	Light grey.

Comparison of Korean coal with other coals from the Central Provinces and Central India

It is difficult to compare the quality of the Korean coals with that of the best-known fields in the Central Provinces and Central India, because of the paucity of published data, the majority of analyses representing isolated samples. However, the following figures taken from Ball and Simpson's memoir may be considered.

TABLE 5.

Comparison of Composition of Kurasia Coal with that of other fields in the Central Provinces and Central India.

—	KURASIA FIELD.	WARORA.	MOHPANI.		PENCH VALLEY BARKUI FIELD.	BALLARPUR.	UMARIA.	JOHILLA.
—	Average of 39 analyses (from p. 183).	Average of 2 samples (prior to 1877).	Average of 10 analyses.	Average of several analyses (*splint*).	Average of 3 samples.	Sample from boring cores.	Average of 13 analyses.	Average of 3 analyses.
Moisture	7·47	11·72	2·52	2·84		11·10	3·71	..
Volatile matter	29·48	29·33	24·26	20·55	22·8	31·56	27·55	34·85
Sulphur	..	1·55	0·51	0·95		..	..	..
Fixed Carbon	48·40	43·80	48·71	37·42	53·5	45·47	56·14	54·43
Ash	14·65	13·60	24·01	38·24	23·6	11·87	12·60	10·72

It is to be regretted that figures showing the average composition of the coal as sold from these various fields are not available. But it is understood that Umaria coal as now sold, and Warora coal as it was sold before the mine was shut down, are much higher in ash than indicated by the foregoing figures; whilst many of the Kurasia analyses (see tables 8 and 10) show lower ash than the solitary Ballarpur analysis given above. It is evident therefore that the Kurasia coal compares favourably with that of all the above fields except, perhaps, Johilla. The Sanhat average (see p. 183) is poor compared with that from all the above fields except Mohpani, but the coal of Murma and Rakeya in the Sanhat field (see p. 191) is not much inferior to that of Kurasia.

Fossils.

Although fossil plants are not uncommon in the coals and associated shales and sandstones, yet few good specimens were obtained. The plants noticed (identified by Babu Bankim Bihari Gupta) were *Glossopteris indica*, *Vertebraria indica* and *Schizoneura*.

Concretions of lithomarge.

At one locality, Upper Dubpani (Kurasia, No. 30), the coal contains concretions of numerous curious white bodies. They are confined to the bright layers, and appeared, when the coal was broken out of the bank in the course of sampling, as white spots suggesting splashes of whitewash. On examination these spots are found to be flattened spheres or oblate spheroids averaging about $\frac{1}{4}$ inch in diameter, and consisting of a soft white minutely crystalline aggregate. These bodies are surrounded by a very thin brown coat, and this by a shell of black coal. From these bodies as nuclei, cracks radiate out into the bright coal in such a way as to suggest the petals of a flower, five in number, giving the whole structure a total diameter of $\frac{3}{4}$ to 1 inch. The general suggestion is of winged seeds, but there seems to be little doubt that the white bodies are of inorganic origin, probably concretionary; the cracks radiating from the nuclei have been caused, doubtless, by a different coefficient of expansion for the nuclei and for the surrounding coal. Under the microscope the white nucleus is seen to be crypto-crystalline like chalcedony, but its softness, of course, precludes it from being this mineral. A quantitative chemical examination of these spheroids carried out by Babu Ajit Kumar Banerjee, Assistant Curator, gave the result shown in column 1 :—

	I	II
SiO_2	45·94	46·5
Al_2O_3	40·03	39·5
MgO	trace	..
H_2O	14·02	14·0
TOTAL .	99·99	100·0

In column II are given the theoretical figures for pure kaolin ($2H_2O. Al_2O_3. 2SiO_2$). In view of the crypto-crystalline character of the concretions as viewed under the microscope the most apt term to apply is probably *lithomarge*. The presence of these concretions of lithomarge is of considerable theoretical interest, for inasmuch as they must have been formed by the segregation of lithomargic material originally distributed through the bright coal in which they occur, their presence adds force to the deduction already drawn on page 180 that the bright coal is of the nature of a colloidal substance that has in some way segregated chemically from admixed earthy materials. The point now to be solved is why bright coal does not contain these lithomargic concretions more frequently.

Correlation of the coal seams.

The coal horizons seem to occur chiefly in the lower and middle portions of the Barakars. Thus, whilst the altitudes of the Barakars in the *Kurasia field* range from about 1,700 feet to 2,900 feet, the measured altitudes of the coal outcrops range from 1,750 to 2,300 feet. The number of horizons is difficult to ascertain with certainty, owing to the difficulty already noticed of correlating the outcrops. But, judging from the outcrops in the Gorghela Nala and its tributaries, the Kurasia field has at least 6 horizons, unless faulting has caused duplication; even then the number of coal horizons must be at least 4. These horizons are numbered 1 to 6 from below upwards, and on the evidence of situation and barometric elevation I have attempted to correlate all the outcrops examined, the results being tabulated in Appendix I (see also pages 197, 201). From this table it will be seen that horizon 4, ranging in elevation from 1,864 feet (Kuar Jharia, No. 45) at the south-western corner of the field to 2,155 feet (Chirra Jharia, No. 21), in the north-eastern corner of the field, suggests a general, very slight, dip to the S. S. W. Workable coal seams appear to occur in horizons 4, 3, and 2.

In the Sanhat field I examined only the southern edge; the coal exposures ranged in elevation from 1,720 feet (Balbahara, No. 10) at the western end of the field to 2,307 feet (Charcha, No. 19) towards the eastern end. They seem all to be referable to two horizons—if I may dare to attempt any correlation—with the exception of one of the Biyah Mandha Nala exposures (No. 13; 2,150 feet) and the Bar Pani exposure (Charcha, No. 19; 2,307 feet). Numbering the seams from below upwards, seam 1 contains workable

coal at the eastern end of the field, and seam 2 at the western end.

It is undesirable to insert in the text of this report the details of all the exposures examined, but they have been tabulated in Appendix I, where they are arranged according to the attempted correlation, horizon by horizon, a serial number being assigned to each outcrop, and inserted both in this table, and on the map (Plates 30 and 31). The numbers commence at unity in each field. The Kurasia field is divided into two sections—Kurasia and Chirmiri—and the exposures tabulated separately. In the Sanhat field and the Chirmiri section of Kurasia, the exposures are numbered in order from east to west. In the Kurasia section the numbering is generally from south to north.

From this table it will be seen that there is an extraordinary variation, both in thickness and in the character of the rocks of the coal series from point to point. Thus the 86 feet of coal of Karar Khoh in the Kaoria Nala (Kurasia, No. 33) is probably represented by the 3′ 5″ seam, thinning to 11 inches, at Dubpani (No. 32) in the same *nala*, only about 1 mile away. Less sudden changes are seen at other points of both fields. These changes indicate that although one horizon seems to have been widely spread yet the conditions of deposition varied widely from point to point.

We are now in a position to deal with each field separately from the economic point of view.

CHAPTER VII.

THE SANHAT COALFIELD.

Correlation of seams.

As already stated, this field has an area of about 330 square miles. The numerous outcrops of coal discovered by Messrs. Hughes and Hira Lal are tabulated in Appendix II, whilst the details of those examined by me are given in Appendix I, from which it will be seen that some of them are exposures not mentioned by Hughes. As already noted, Hughes did not succeed in correlating the various exposures, and it is only with great hesitation that I have ventured to correlate those examined by me along the southern margin of the field, the data employed being general elevation and distance from the Talchir boundary. Only by a careful examination of all the intervening nalas could the probability of the correlation be maintained or disproved ; and certainty can never be attained without boring operations. A summary of the correlation shown in Appendix I is given here :—

TABLE 6.

Correlation of Sanhat Coal Seams.

	Horizon 1.			
(1) 1,965 ft. .	Murma (Pharkapani N.)	7′9″+	coal.	Sample K. 42.
(2) 1,855 ft. .	Rakeya (Parewa Ghag)	4′4″	coal in 5′3″ seam.	„ K. 43.
(3) 1,925 ft. .	Charcha (Diwan Dham N.) . .	2′+	coal.	
(4) 2,010 ft. .	Nagar (Biyah Mandha N.) . . .	9″	coal.	
(5) 1,973 ft. .	Nagar (Dummar Nakha N.) . . .	9′	coal.	„ K. 45.
(6) 1,800-1,870 ft.	Harra (Tutina Jharia)	Up to 6′	coal.	
(7) 1,827 ft. .	Harra (Ghogra N.)	1′2″	coal.	
(8) 1,800 ft. .	Kirwahi Ghag	2′6″	coaly shale.	
(9) 1,745 ft. .	Dhuneti Ghag	3′	carbon shale.	
(10) 1,720 ft. .	Balbahara (Soa Pani)	7″	coal.	
	Horizon 2.			
(11) 2,165 ft. .	Rakeya (Saman Dei N.)	14″+	coal (2 seams).	
(12) 2,125 ft. .	Sardih (Gae-mara N.)	1′7″	coal and coal shale.	
(13) 2,150 ft. .	Nagar (Biyah Mandha N. 2A) . .	4′	coal.	Sample K. 44.
(14) 2,116 ft. .	Do. Do.	2′	coal.	
(15) 1,918 ft. .	Kirwahi (Pakri Dabra N.) . . .	2′	coal.	
(16) 1,935 ft. .	Ghutra (Dhuneti N.)	3½′+	coal.	„ K. 46.
(17) 1,978 ft. .	Salba (Sitamarhi N.)	4′11″+	coal in 7′8″ seam.	„ K. 47.
(18) 1,885 ft. .	Balbahara (Soa Pani)	9′9″	coal (2 seams)	„ K. 48. „ K. 49.
	Horizon 3.			
(19) 2,307 ft. .	Charcha (Bar Pani)	2′9″	coal (3 seams).	

Horizon 1.

Assuming the possible correctness of this correlation, it will be noticed that the seam in the lower horizon (No. 1) is thick enough to be worth investigation at four localities (Nos. 1, 2, 5, and 6) distributed over a length of about 16 miles at the eastern end of the field, whilst the seam at one other locality (No. 3) shows 2′+ of coal. The samples from this horizon gave the following analytical results :—

—	Murma, No. 1.	Rakeya, No. 2.	Nagar, No. 5.
Sample number.	K. 42.	K. 43.	K. 45.
Moisture	8·20	6·00	3·18
Volatile matter	29·50	28·16	26·98
Fixed carbon	46·34	50·46	37·60
Ash	15·96	15·38	32·24
Total	100·00	100·00	100·00

Quantity of coal.

At Murma and Rakeya the coal is evidently of good enough quality to be worth working, if it can be proved to exist in sufficient quantity. On the other hand the coal of Nagar further west is of little value and it is consequently impossible to put forward even the roughest of estimates concerning the quantities of workable coal in horizon 1. It is sufficient to say that every square mile of coal of 5 foot thickness in the Murma and Rakeya area probably contains some $5\frac{1}{2}$ million tons of workable coal (assuming 1·4 as the specific gravity of the coal).

Horizon 2.

The next seam above (horizon 2) is of no value at the eastern end of the field, but at Nagar in the centre of the field, and at three localities towards the western end, namely Ghutra, Salba, and Balbahara, (Nos. 13, 16, 17,

18), thicknesses from $3\frac{1}{2}'+$ to $9'\ 9''+$ were measured. The samples from these localities gave the following results on analysis :—

—	NAGAR (13).	GHUTRA.	SALBA.	BALBAHARA.	
Sample number.	K. 44.	K. 46.	K. 47.	K. 48.	K. 49.
Moisture	3·38	5·48	3·28	5·71	3·10
Volatile matter . .	25·62	21·06	23·58	26·33	23·40
Fixed carbon . . .	47·86	41·78	50·16	43·38	36·82
Ash	23·14	31·68	22·98	24·58	36·68
TOTAL .	100·00	100·00	100·00	100·00	100·00

On the evidence of the foregoing analyses, the coal of horizon 2 is of low grade, but it is possible that some of the coal might be considered worth working once railway facilities had been provided ; one must remember that outcrop coal is often inferior to the fresh coal obtained some distance in from the surface. If it be considered desirable to investigate this area further, then in the first place the water-courses between Nagar and the more westerly exposures should be searched for outcrops, whilst particular attention should be given to the western group of exposures, where the flatness of the ground would mean but a small expenditure on boring. As regards thickness the Balbahara outcrop is particularly promising ; it is apparently the 10 foot seam discussed by Hughes on page 199 of his memoir, of which he gives the analyses repeated below on page 194. Only 7′ 3″ of this thickness was visible at the time of my visit because heavy rain had filled up a hollow at the foot of the seam, thus obscuring the lower part. The Balbahara analyses given above correspond to very poor coal, but those quoted on page 194 indicate much more favourable prospects.

Quantity of coal.

The exposures indicate the existence of considerable quantities of coal in this area, but the data are too few for any estimate of quantities to be attempted. It is sufficient to say that every square mile of coal-bearing ground proved in the Ghutra-Balbahara neighbourhood means on an average

thickness of 5 feet, $5\frac{1}{2}$ million tons of coal, assuming an average specific gravity of 1·4.

Western end of field.

I was unable to visit the most westerly portion of this field, stretching for some 16 miles from Ghutra to Kelhari on the western border of the State. Consequently I sent Babu Bankim Bihari Gupta, Field Collector, to sample several outcrops in this area. His notes on the sections are given in Appendix I and are summarised here :—

(20) Bahi (Papar Jhorka) .	3′5″ seam (3′3″ coal).
(21) Bahi (Hasia Nala) .	3′1″ seam (2′6″ coal).
(22) Khurpidhar . .	3′9″ seam (3′ coal).
(23) Putadand . . .	4′7″+ coal.
(24) Kerabahara (Gilapani N.)	4′7″+ coal.
(25) Karwabara Nala .	3′5″+ coal.
(26) Bichatola . .	1′11″ coal.
(27) Barni Nala . .	$11\frac{1}{2}$″ coal in 2 seams.

The following are the analyses of the samples taken :—

—	Papar Jhorka.	Khurpi Dhar.	Putadand.	Gilapani Nala.
Sample number.	K. 50.	K. 51.	K. 52.	K. 53.
Moisture	4·14	2·32	2·96	4·50
Volatile matter	18·44	15·70	13·56	26·34
Fixed carbon	54·48	46·10	42·00	44·78
Ash	22·94	35·88	41·48	24·38
Total .	100·00	100·00	100·00	100·00

I am, of course, unable to correlate these exposures with horizons 1 and 2 further east; but it is evident that the coal is of the same low grade as that of horizon 2 in the Balbahara-Ghutra area; the composition and thickness of the seams do not encourage further investigation, except at Gilapani Nala and Papar Jhorka, where the level nature of the country should facilitate the prospecting of these outcrops by boring, if considered desirable.

Previous analyses.

For comparison with the foregoing analyses of coals from the Sanhat field I reproduce the following from Hughes' memoir :—

——	Balbahara.				Kara-kachar Nadi.	Nerua.	Remarks
Volatile matter .	28·85	30·42	27·84	29·03	9·84	29·57	All non-caking.
Fixed carbon .	53·42	57·51	51·32	54·09	49·52	53·29	
Ash . . .	17·73	12·07	20·84	16·50	40·64	17·14	
Total .	100·00	100·00	100·00	100·00	100·00	100·00	..
Hygroscopic and combined water.	6·4	5·68	5·6	5·92	2·26	8·28	..

and also the following analyses from Mr. J. L. H. Harris' report and the Geological Survey (samples furnished by the Superintendent, Korea State) :—

——		Moisture.	Volatile matter.	Fixed carbon.	Ash.
1. Kohi Madda Nala .	J. L. H.	6·20	32·64	50·06	11·30
2. Parewa Ghag . .	„	7·40	31·11	49·83	11·67
3. Murma (Karimati East)	„	8·20	31·76	46·72	13·32
4. Bar Pani (Charcha) .	„	4·00	25·61	48·15	22·24
5. Nagar	„	4·50	21·55	39·40	34·55
6. Nagar	G. S. I.	5·44	22·00	39·90	32·66
7. Jura Nala (Harra) .	J. L. H.	3·50	26·06	36·86	33·58
8. Jharia Nala (Harra) .	G. S. I.	4·48	27·74	41·44	26·34
9. Khurpi Dhar . .	J. L. H.	2·00	8·65	45·10	44·25
10. „ (Putadand) .	G. S. I.	2·44	9·26	32·88	55·42
11. Bahi (Papar Jhorka) .	„	4·64	7·90	4·66	82·80

CHAPTER VIII.

THE KURASIA COALFIELD.

This, the second of the Korean coalfields in point of size, has an area of about 48 square miles according to Hughes, being some 10 miles long from west to east and 6 broad from north to south. It is an outlier entirely surrounded by Talchirs, except along its northern margin, where it is covered by the southern edge of the dolerite sill described on page 156. As far as one can ascertain from traversing this field, it has an average horizontal dip, with very gentle rolling about axes aligned in various directions; but there is probably a very slight general dip towards the south or south-west of the order of some 290 feet in 8 miles, this dip being deduced from the difference between the elevations of the Kuar Jharia (No. 45) and the Chirra Pani (No. 21) exposures of horizon 4, on the assumption that the correlation is correct.

Dips.

Messrs. Hughes and Hira Lal were unable to devote more than a very short period to the survey of this field, and consequently discovered only 7 outcrops of coal (*Mem. G. S. I.*, XXI, p. 203). One of these, of excellent quality (that given as 13′6″ thick), is probably the outcrop listed as Bijaura Jharia (No. 7) in Appendix I. The second outcrop is 1½ miles S. S. E. of Kurasia, apparently in a tributary of the Kudra Nala. It is 6½ feet thick, and has an excellent analysis, but was not visited by me. The third outcrop, 8 feet thick, in the 'Gorgheta' corresponds with my Gorghela Nala (No. 4) of the same thickness. Owing to their inferior character details of the other exposures are not given, but three of them lie towards the western end of the field and are important as proving the extension of coal in that direction.

Messrs. Hughes and Hira Lal.

During my own visit I was able to examine only those outcrops lying within reach of the villages of Chirmiri and Kurasia, and even then I was compelled to omit some of the outcrops known to the villagers. In Appendix I, I have given details of all the outcrops examined (except No. 33, see page 205) and in Tables 8 and 10 (pages 199 and 203) are shown the analyses of the samples taken.

Aneroid readings.

A brief discussion of the probable relationships of the outcrops is, however, necessary. In the first place, it is important to emphasise the point, already made on page 178, that with very rare exceptions the coal crops out only in the *nalas* or water-courses, being entirely covered by soil, débris, and jungle, on the intervening slopes and spurs. Any correlation of outcrops is, therefore, not a matter of certainty, but of probability. The dips being as a rule *nil* or very gentle, the aneroid is obviously as important as the hammer in this work, and the former instrument was tested to the full. My two base stations were my camp at Chirmiri, fixed as 2,100 feet by comparison with Bartunga Hill (△ 2,917 feet) and my camp at Kurasia, fixed as 2,200 feet by comparison with Kurasia Hill (△ 2,847 feet). But although the difference in height between these two camps was by these measurements just 100 feet, yet on the two occasions when I travelled from one to the other, the difference appeared to be greater (230 and 155 feet respectively); but in each case I attribute these differences to unsettled weather, and prefer to rely upon the results of direct comparison with the hills mentioned. I have dealt with this point in detail because on the relative heights of these two camps depends any attempt at correlation between the outcrops observed from Chirmiri with those examined from Kurasia. On the relative heights of the outcrops observed from one camp alone considerable reliance may be placed, because of the careful application I made throughout the day of corrections for diurnal variation, using a scale of corrections locally determined, and because in each case I returned after the day's work to my starting point and was able to distribute any error caused by weather changes, which, however, were mostly very small whilst I was examining this field.

A. The Kurasia Area.

As the Gorghela Nala gives a good section of the field, I will discuss the Kurasia area first, confining this term to that portion of the field lying east of the ridge on which runs the road from Kurasia to Dubchola. In the Gorghela itself I saw only 4 seams (including Kundo Pani, the headwater of the Gorghela); but taking into account outcrops seen in tributaries of this *nala* (Nag Jhula, Saruplikha Nala, Bansa Dandi, etc.) we may count 5 horizons in all, with perhaps

Correlation of seams.

a sixth, in the second Kundo Pani outcrop : the last is the head-water of the northward-flowing Kurasia Nala, for both the Gorghela and the Kurasia Nala rise at about the same spot. The height assigned to each series of outcrops in Appendix I is that of the top of the highest coal. The horizons may be numbered from 1 to 5 (or 6) from below upwards, the numbers really attaching to coal horizons rather than seams, for there may be one or more seams at each horizon, separated by stone or coaly shale.

With these premises I may give the following abstract from Appendix I, showing the most probable correlation of outcrops, differences of elevation of the same seam being attributable partly to gradual dips in the succession of rocks, partly probably to local folds giving rise to sharper dips, partly no doubt to local faults, and partly to errors in the barometric readings. It is just possible, moreover, that larger faults not discovered may be leading me to an entirely erroneous correlation, as for example between the out-crops in the Gorghela and its tributaries on the one hand, and those lying east and north of Kurasia on the other.

Table 7.

Correlation of Kurasia Coal Seams.

	Horizon 1.		
(1) 1,761 ft.	Gorghela Nala	30″ coal (9 seams) in 16′10″.	Sample K. 41.
(2) 1,750 ft.	Trib. of Gorghela N.	1′ 2″ coal stringers.	
(3) 1,790 ft	Gatti Jharia (Do.)	24″ coal (4 seams) in 4′10″.	
	Horizon 2.		
(4) 2,011 ft.	Gorghela N.	8′ coal	Samples K. 25, 26.
	Horizon 3.		
(5) 2,052 ft.	Gorghela N.	2′+ coal.	
(6) 2,060 ft.	Daukihuri	3′10″ coal	Samples K. 27, 28.
(7) 2,045 ft.	Bijaura Jharia	11′6″ coal (+4′ obscured) (? one seam).	„ K. 33, 34, 35.
(8) 2,021 ft.	Do. trib.	4′3″ coal.	
(9) 2,061 ft.	Lachman Jharia	3′2″ coal	Sample K. 37.
(10) 2,049 ft.	Chirra Jharia	4″ coal.	
	Horizon 4.		
(11) 2,129 ft.	Nag Jhula	6′8″ coal (5 seams) in 12′7″.	Sample K. 31.
(12) 2,123 ft.	Ghumasarai N.	2′4″ + coal (2 seams) in 4′10″.	„ K. 32.
(13) 2,126 ft.	Saruplikha N.	8′6″+ coal (3 seams) in 11′1″.	Samples K. 29, 30.

Correlation of Kurasia Coal Seams—contd.

	Horizon 4—contd.		
(14) 2,122 ft. .	Ama Jharia	2′10″ coal (2 seams) in 8′6″	
(15) 2,083 ft. .	Bansa Dandi	1′10″+ coal (2 seams)	
(16) 2,117 ft. .	Bijaura Jh.	+4″+coal.	
(17) 2,137 ft. .	Lachman Jh.	4′+ coal (? second seam at 2,142′)	Sample K. 36.
(18) 2,126 ft. .	Do. trib.	2½′+ coal (2 seams) in 9½′.	
(19) 2,124 ft. .	Do. do.	2′10″ coal.	
(20) 2,102 ft. .	Do. do.	+3½′+ coal.	
(21) 2,155 ft. .	Chirra Jh.	+2′6″+ coal (2 seams) in 9½′.	
(22) 2,125 ft.[1] .	Do.	8′2″ coal (2 seams) in 22½′.	„ K. 38.
(23) 2,092 ft. .	Kurasia N.	2′6″ coal.	
(24) 2,036 ft. .	Do. repeated	4′+ coal (2 seams) in 4′4″.	
(25) 2,062 ft. .	Dudhania N.	1′ coal.	
	Horizon 5.		
(26) 2,209 ft. .	Kundo Pani	+3′9″ coal (2 seams) in 5′1″	
(27) 2,222 ft. .	Kukri N.	+3′5″ coal (2 seams) in 4′10″.	
(28) 2,197 ft. .	Ama Jharia	3½′ coal . .	Sample K. 39.
	Horizon 6.		
(28A) 2,312 ft.[2] .	Kundo Pani	coal indications.	

The largest chances of erroneous correlation are the following :—

The last four outcrops (nos. 7 to 10) placed under horizon 3 may really belong to horizon 2. They are placed with horizon 3 on the ground of their distance (70—100 feet) below outcrops of horizon 4 in the same *nalas*, this agreeing with the vertical distance (77 feet) between Nag Jhula and Gorghela (horizon 3), rather than that (118 feet) between Nag Jhula and Gorghela N. (horizon 2).

The two outcrops (nos. 21 and 22) in Chirra Jharia placed in horizon 4 are assumed to belong to the same horizon repeated by faulting or folding, as in the more certain case of the two outcrops in Kurasia Nala (nos. 23, 24).

Finally Kundo Pani (no. 28A, horizon 6) might be Kundo Pani (no. 26, horizon 5) repeated ; but a rather sharp fault would be required.

Analyses.

For comparison with the foregoing correlation I give below the results of the analysis of the coal samples arranged according to horizon :—

[1] ? horizon 3 or 4, repeated by folding or faulting.
[2] Possibly only horizon 5 repeated.

TABLE 8.

Analyses of Kurasia Coals.

	Horizon 1.	Horizon 2.		Horizon 3.						Horizon 4.						Horizon 5.
	K. 41.	K. 25.	K. 26.	K. 27.	K. 28.	K. 33.	K. 34.	K. 35.	K. 37.	K. 31.	K. 32.	K. 29.	K. 30.	K. 36.	K. 38.	K. 39.
—	*Gorghela N.* 23″ coal in 7 thin seams.	*Gorghela N.* Top 4½′ of 8′ seam.	*Gorghela N.* Bottom 3½′ of 8′ seam.	*Daukihuri.* 2′ of 3′ 10″ seam.	*Daukihuri.* 1′ 4″ coal.	*Bijaura Jharia.* 4′ 3″ top of upper seam.	*Bijaura Jharia.* 4′ 8″ lower part of upper seam.	*Bijaura Jharia.* Basal 2′6″ (? a second seam).	*Lachman Jharia.* 3′2″ coal.	*Nag Jhula.* 5 seams totalling 6′8″.	*Ghumasarai N.* 2′ coal.	*Saruplikha N.* Upper seam lower 2′.	*Saruplikha N.* Second seam 2½′.	*Lachman Jharia.* Upper seam 4′ coal.	*Chirra Jharia.* Lower 4½′ coal.	*Ama Nala.* 3′6″ seam (shale-coal rejected).
Moisture . .	4·73	6·38	4·76	9·76	10·68	2·78	2·54	2·44	8·94	9·10	8·42	10·74	7·68	8·50	7·52	10·02
Volatile matter .	29·25	27·84	26·52	32·10	34·56	27·78	21·76	30·38	29·68	30·12	30·70	31·04	31·32	31·04	31·30	31·06
Fixed carbon .	45·88	56·28	56·14	43·08	46·92	60·86	54·98	53·74	46·96	46·96	49·88	48·90	49·22	49·42	48·78	45·64
Ash . .	20·14	9·50	12·58	15·06	7·84	8·58	20·72	13·44	14·42	13·82	11·00	9·32	11·78	11·04	12·40	13·28

On comparing the two sets of figures it at once becomes evident that in horizon 4 we have a group of seams of sufficient thickness and high enough quality to deserve very careful investigation. In fact, it will be noticed that in most of the cases where the observed thickness of coal is small the full thickness was not exposed, and it seems likely that a minimum average thickness of 5 feet of coal may be expected. The map indicates the possible extension of this seam over at least 4 square miles in the Kurasia area. And, as has already been noticed (see p. 191), every square mile of coal of this thickness means a quantity of 5½ million tons.

Horizon 4.

Horizon 3 also looks very promising at Bijaura Jharia, where 11½ feet of coal broken into two portions by 4 feet of obscured ground allows a possibility of 15½ feet of coal. This thickness, however, decreases to only 4′3″ in a tributary a short distance away.

Horizon 3.

The 8 foot seam of Gorghela Nala taken as horizon 2 has not been detected elsewhere, but in view of its good quality (see analyses K. 25, K. 26, Table 8) it seems worthy of further investigation.

Horizon 2.

It seems in most cases unprofitable to suggest sites for boreholes in advance of any actual proposal to resort to such operations; but I cannot resist the temptation to point out a most desirable site for testing nearly the whole vertical succession of coal horizons in this field. This site is in the low ground immediately north of Kurasia village, somewhere near the hollow tree-trunk embedded in clay that serves as the village well. Such a hole would probably be too low for horizons 5 and 6, but would pass through all the others, if there are no complications due to faulting. My reading for the height of this well is 2,164 feet, so that horizons 4, 3 and 2 should be encountered in the first 200 feet of the bore-hole suggested.

Site for borehole.

B. The Chirmiri Area.

We may now consider the correlation of the coal seams in the Chirmiri area one with another, and with those of the Kurasia area. The most important exposure is that occurring at the waterfall in the Kaoria Nala known as Karar Khoh, and also for some distance down the bed of the Kaoria Nala, and up its side tributaries. The 36 feet of coal,

Correlation of seams.

grouped into 7 seams in the section given on page 205, are distributed through a total thickness of 48 feet of coal and associated rock, and the correlation of such a horizon becomes therefore of the greatest importance. With the other outcrops in the Chirmiri area I can correlate it with some confidence, but in the correlation of the Kurasia and Chirmiri series with each other there is considerable uncertainty partly because the Chirmiri seams appear to be much more disturbed and variable in thickness than those of Kurasia, and partly because bad weather disturbed the barometer when I attempted to effect the correlation. However, it seems probable that the Karar Khoh series taken as a whole corresponds to horizon 4 of the Kurasia area, and on this supposition the following correlation may be advanced, the outcrops being arranged geographically from east to west (see Appendix I for details) :—

TABLE 9.

Correlation of Chirmiri Coal Seams.

	Horizon 3.		
(29) 1,816 ft. .	Kachhan Kundi	11″ coal in squeezed beds (p. 173).	
	Horizon 4.		
(30) 2,110 ft. .	Upper Dubpani	4½′ coal. . .	Sample K. 40.
(31) 2,070 ft. .	Chirmiri N.	11″ coal.	
(32) 2,030 ft. .	Dubpani	12″, 3′, and 3′5″, coal in 3 exposures.	
(33) 1,940 ft. .	Karar Khoh and Hathbandha N. .	36′ coal in 48′ (7 seams).	K. 2 to K. 14.
(34) 1,910 ft. .	Sare N.	17′6″+ coal in 54′, of which 27½″ obscured (5 seams).	
(35) 1,877 ft. .	Gae-mara N.	19′ to 21′+ coal in 24′ (3 seams).	
(36) 1,964 ft. .	Do. trib.	13½′+ coal in 29′ (4 seams).	K. 24.
(37) 1,907 ft. .	Trib. of Kaoria N. below Hathbandha N.	11′ coal in 11′6″ (2 seams).	
(38) 1,887 ft. .	Barsi Pani	18½′+ coal in 30′ 10″ (4 seams).	
(39) 2,045 ft. .	Manju Nacha N.	+2′+ coal.	
(40) 2,005 ft. .	Diwan Jharia	4½′ coal in 5½′ (2 seams).	K. 20.

Correlation of Chirmiri Coal Seams—contd.

	Horizon 4—contd.		
(41) 1,992 ft.	Karauli Dhar	3′+ coal	K. 19.
(42) 1,941 ft.	Kachhan Kundi	2′+ coal.	
(43) 1,902 ft.	Do.	13″ coal.	
(44) 1,936 ft.	Paraspani N.	14″ coal.	
(45) 1,864 ft.	Kuar Jharia	11″ coal in 18″ (2 seams).	
(46) 1,889 ft.	Jam N.	1′10″coal in 10′4″ (2 seams).	K. 18.
(47) 1,879 ft.	Bija N.	11″ coal in 4′11″ (2 seams).	K. 17.
(48) 1,879 ft.	Bhalubhil Jharia	5½′ coal (and shale) in 14′ (2 seams).	K. 16.
(49) 1,865 ft.	Am Nala	3′ coal (and shale)	K. 15.
	Horizon 5.		
(50) 2,103 ft.	Trib. of Karauli Dhar	+1′ coal.	
(51) 2,093 ft.	Bara Am N.	10″ +coal.	
(52) 2,104 ft.	Bare Mandil N.	7′9″+ coal in 33′ 1″ (3 seams).	K. 23′.
(53) 2,109 ft.	Sendri Ama N.	7′8″+ coal in 27½′ (2 seams).	
(54) 2,118 ft.	Bijaura N.	4′ coal.	
(55) 2,139 ft.	Mangarmuhar N.	9′2″+ coal in 33′7″ (3 seams).	K. 21, 22.
(56) 2,161 ft.	Samardhukela N.	2′2″+ coal.	
(57) 2,157 ft.	Trib. of Kachhan Kundi	+3′+ coal.	
(58) 2,162 ft.	Am Jharia	+2′ coal.	

Of the outcrops grouped in horizon 4 the least certain are the 5 exposures on the S. W. side of Bartunga Hill or Kadrewa Hill (in the Kuar Jharia and its tributaries); these might perhaps be equally well grouped in horizon 3. The difference of elevation between the Kachhan Kundi and Karar Khoh exposures and the Kuar Jharia is, however, less than that between the Karar Khoh and Dubpani exposures, and may indicate a general slight south-westerly dip (see p. 172).

Analyses.

For comparison with the foregoing correlation I tabulate below the analytical results of the samples taken, excluding those of the Karar Khoh section, which are tabulated on page 206 :—

TABLE 10.

Analyses of Chirmiri coals.

	Horizon 3.									Horizon 5.		
	K. 40.	K. 1.	K. 24.	K. 20.	K. 19.	K. 18.	K. 17.	K. 16.	K. 15.	K. 23.	K. 21.	K. 22.
—	*Upper Dubpani.* (No. 30) 4′6″ seam (9″ coal shale excluded).	*Dubpani* (No. 32) 2′ 8″ sampled.	*Gae-mara N. trib.* (No. 36) 4′ coal, top seam.	*Diwan Jharia* (No. 40). Upper seam, 3-4′.	*Karauli Dhar* (No. 41). Top 1½′ of 3′ seam.	*Jam Nala* (No. 46). 10″ coal.	*Bija Nala* (No. 47). 8″ coal.	*Bhalubhil N.* (No. 48). 1′3″ coal.	*Am Nala* (No. 49). 3′ seam picked.	*Bare Mandil N.* (No. 52). 3′6″ coal.	*Mangarmuhar N.* (No. 55). 4′ coal —upper seam.	*Mangarmuhar N.* (No. 55). 1½′-3′ from lower seam.
Moisture . .	7·86	14·42	7·12	8·60	10·24	9·70	10·16	7·66	9·42	7·48	6·42	8·44
Volatile matter .	30·52	31·48	31·74	30·80	29·70	33·84	32·04	25·84	30·58	26·34	29·14	29·18
Fixed carbon .	52·20	44·85	51·34	46·76	47·20	47·26	49·22	47·50	33·60	41·92	34·78	48·24
Ash . . .	9·42	9·25	9·80	13·84	12·86	9·20	8·58	19·00	26·40	24·26	29·66	14·1
TOTAL .	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

NOTE.—None of the samples caked, but K. 24 sintered slightly.

Horizon 4.

On scanning the list of exposures of horizon 4 it is seen that those of workable thickness are confined to the Kaoria Nala at Karar Khoh and the neighbouring tributaries, with the possible exception of the Diwan Jharia and Upper Dubpani exposures.

The Karar Khoh section, Kaoria Nala.

In fact we need discuss here only the Karar Khoh area. This section being so important has not been relegated to the Appendix, except in a summarised form, and will be given in full below.

After leaving behind the Dubpani exposure (No. 32) and continuing down the stream (which now becomes termed the Kaoria Nala) for nearly a mile over typical Barakar sandstone, below which the Dubpani exposure has dipped, one at last reaches a small fall over pot-holed sandstones, at the base of which lie some 3 feet of micaceous carbonaceous shales at an elevation of 1,988 feet. The overlying gritty sandstone itself contains several stringers of coaly matter in its basal 2 feet. Continuing westwards down the small gorge the shales are found to increase in thickness to 4½ feet (including some sandy layers), resting on some 6 inches of very black shale, which itself rests on greenish, micaceous sandstone. There is now a gentle dip to S. S. E. After descending over some 10 feet of these bedded sandstones, a tributary joins from the south and then a few yards below the junction there commences the waterfall known as the Karar Khoh. This fall passes over seams 1 to 3A of the section given below, and at its base is a pool carved out by the falling water. Passing this pool, and continuing down the stream bed, the top of seam 4 is found cropping out at intervals in the banks on both sides, and in the bed itself, there being evidently a slight roll about a N. E. axis, so that the rocks are soon dipping to the N. W. Some little distance down stream the base of seam 4 is found on the top of a striking barrier or dam of coal (Plate 29) stretching across the river-bed from bank to bank. This dam, which is 11 feet high, consists, except for 1 foot of shale at the very top, entirely of seam 5. A lower 2 feet of this seam crops out for some 30 yards further down stream, and then the underlying argillaceous and rather fine-grained sandstones appear, soon passing down into the typical coarse-grained Barakar sandstones. Between the Karar Khoh fall and the coal barrier a good section ranging from seam 1 to the top of seam 4 is exposed in the Hathbandha Nala, a steep ravine joining the left bank

of the Kaoria Nala. The Kaoria Nala below the Karar Khoh is shut in on either bank by vertical cliffs of Barakar sandstone some 80 to 100 feet high, and their débris hides the underlying coal seams, except where mentioned above. As the result of careful measurements the following section has been constructed :—

....	Coarse-grained sandstones	....
5′ 0″	Carbonaceous shale	....
32′ 0″	Bedded, fine-grained, argillaceous sandstone	....
4′ 7″	Interlaminated sandstones and shales	....
1′ 6″	Carbonaceous shale	....
4′ 6″	*Seam 1.*—Banded bright and dull coal	Sample K. 5.
11″	Carbonaceous shale	....
3′ 0″	Carbonaceous sandstone with black shale (the steep part of the waterfall begins here).	....
4′ 0″	*Seam 2.*—Similar coal to seam 1	Samples K. 6, K. 7.
5″	Black shale	....
6″	*Seam 2A.*—Bright coal	....
1′ 4″	Coaly shale	....
4′ 0″	*Seam 3.*—Dull coal with thin bright layers	Samples K. 2, K. 8.
1′ 1″	Black coaly shale	Sample K. 8.
8″	*Seam 3A*—Mostly bright coal—rather pyritic	,, K. 9.
2′ 6″	Micaceous sandstone (the surface of the pool is 14″ below the top of this).	....
9″	Black shale	....
12′ 0″	*Seam 4.*—Mostly silky or dull coal	Samples K. 4, K. 10, K. 11, K. 12.
1′ 0″	Black shale	....
12′ 0″	*Seam 5.*—Similar to 4, except for basal 2 feet, which is brighter coal.	Samples K. 13, K. 14.
....	Fine-grained argillaceous sandstones passing down into typical coarse-grained sandstones.	....
TOTAL . 91′ 9″	*91′ 9″ containing 37′ 8″ coal.*	

For comparison with the section, I give below the results of analysis of the samples taken. K. 2, K. 3, and K. 4, represent merely selected specimens, whilst the others are all bulky samples taken to represent the full thickness sampled. K. 2 represents a 3″ band of entirely dull coal in seam 3, and K. 3 the 13″ band of coaly shale between seams 3 and 3A, whilst K. 4 is a typical piece of dull coal from seam 4. The analysis of K. 3 is surprisingly favourable, and if future work confirms this result, then obviously seams 3 and 3A and the intervening coal shale can be worked as one seam of 5′9″ thickness. Unfortunately no specimens or samples of the shale separating seams 2 and 2A, and seams 2A and 3 were taken; but there seems to be a possibility that they might all be regarded as one seam of a thickness of 12 feet (including seam 3A). At present, however, it will be convenient to retain the original numbering. The bulk samples of seams 1 to 3A were taken in the Hathbandha Nala, and those of 4 and 5 from the bed and barrier in the Kaoria Nala, the top of seam 4 being sampled in the Hathbandha Nala. It will be noticed that the thickness of seams 3 and 3A sampled in the Hathbandha Nala is slightly greater than in the Karar Khoh section.

TABLE 11.

Analyses of Coal Samples from Kaoria Nala (Karar Khoh, and Hathbandha Nala).

—	K. 2.	K. 3.	K. 4.	K. 5.	K. 6.	K. 7.	K. 8.	K. 9.	K. 10.	K. 11.	K. 12.	K. 13.	K. 14.
	Handspecimen of 3" band dull coal in seam 3.	Handspecimen of 13" coaly shale between seams 3 and 3A.	Handspecimen of dull coal from seam 4.	*Seam 1*—4' 6"	*Seam 2*—Central 2'	*Seam 2*—Top 1' Basal 1'	*Seam 3*—4'8", excluding 4" shale.	*Seam 3A*—9½"	*Seam 4*—Top 4'	*Seam 4*—Central 3'8"	*Seam 4*—Basal 4'4"	*Seam 5*—Top 10'	*Seam 5*—Basal 2'.
Moisture	3·80	6·16	4·74	8·72	8·08	9·08	6·70	8·74	8·12	6·24	6·74	8·04	8·96
Volatile matter	22·28	27·76	19·90	30·36	27·62	29·84	27·38	33·86	28·09	23·48	31·96	29·32	32·88
Fixed carbon	38·96	49·66	43·30	49·80	52·86	51·94	49·20	49·94	48·08	54·20	52·00	51·28	52·66
Ash	34·96	16·42	32·06	11·12	9·44	9·14	16·72	7·46	15·71	16·08	9·30	11·36	5·50
TOTAL .	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Caking properties. Sample K. 9 is the only one that caked. K.5, K.6, K.7, K.8, K.10, K.12, sintered slightly. The others did not cake at all. The ash in every case was brown to reddish brown.

Giving due weight to the thickness of each seam the following average composition may be assigned to the 37′ 8″ of coal forming this section :—

—	Average.	Limits.
Moisture	7·7	6·2 to 9·1
Volatile matter	29·1	23·5 to 33·9
Fixed carbon	51·2	54·2 to 48·1
Ash	12·0	5·5 to 16·7
TOTAL .	100·0	..

Northwards of Karar Khoh, portions of the Karar Khoh series are seen in exposures 34 to 38, 11′+ to 21′+ of coal being visible.

Extension of the Karar Khoh series.

But in this direction the series has evidently been disturbed, for in the tributary of the Gae-mara Nala the series must be faulted up ; whilst no exposures were found in the Manju Nacha Nala (No. 39) at the expected altitude, possibly owing to jungle and débris, but more probably on account of faulting. Time did not allow me to examine the multitude of *nalas* intervening between this point and Chitajhor, and it is possible that the thick series may be picked up again in that direction. But it is significant that Mr. Harris, who visited Chitajhor, saw only a thin seam (5 to 6 feet) in the Kheradol Nala. In its southward extension this series is obviously limited by the cliffs forming the southern edge of the coalfield, and, since the Karauli Dhar and Diwan Jharia show only 3 to 5 feet of coal in all, it is obvious that the series has thinned out to the south, both in number of seams and total thickness. A little less than a mile due east the Karar Khoh series appears to be represented by the Dubpani exposures (12″ to $4\frac{1}{2}$′ coal), whilst $1\frac{1}{2}$ miles to the west it is apparently represented by the Paraspani Nala and Kachhan Kundi exposures (13″ to 2′ coal). It looks, therefore, as if the Karar Khoh series corresponds with the approximate centre of a basin of coal deposition that thinned rapidly in all directions, except possibly to the north : where, however, if it

once existed as a thick series, it has since been largely denuded away and perhaps previously faulted up.

Quantity of coal.

But the coal at Karar Khoh is so thick that it would repay working, even if boring should prove the existence of only a relatively small area of thick coal. Assuming a uniform rate of thinning from Karar Khoh to Dubpani, Diwan Jharia, and Kachhan Kundi, the maximum possible area of 10′ thickness and upwards appears to be about 2 square miles; but, allowing for a rather sudden thinning, one should not count on more than 1 to 1½ square miles of this thickness. But it is of course possible that the series may retain a thickness of at least 20 feet over as large an area as a square mile. In order that the prospective miner may know what quantity of coal he might expect to prove, it is sufficient to state that 1 square mile of area, if of 10′ thickness, corresponds to 10·9 million tons of coal, and, if of 20′ thickness, to twice that amount, namely, 21·8 million tons. Considering all the data, it seems to me likely that boring operations in this locality will prove the existence of at least 7 million tons of coal of good quality within one square mile, with the possibility of anything between this amount and 20 to 30 million tons.

Horizon 5.

Attention has been concentrated on the Karar Khoh series (horizon 4), but a glance at the list in table 9 will show that the possibility of workable coal in horizon 5 round Bartunga Hill may be worth consideration. Horizon 5 does not, however, cover a greater area than about ¾ square mile in Bartunga Hill.

C.—General.

Conclusions concerning the Kurasia field.

In view of the excellent quality of the coal in the two portions of this field—Kurasia and Chirmiri—and the considerable quantities of such coal that in all likelihood exist, probably some 10 to 20 million tons in each area, with possibilities of considerably larger amounts, this field is well worth the expenditure of considerable sums on boring operations. The chief difficulties that will be encountered in this field are probably small faults, and rapid changes in the thickness of the seams.

Other localities for coal.

Coal has also been found in this area at several localities not visited by me. The following is a list :—

Chirmiri village :—
Sitamati, Mensarai Jharia, Sitakandh Jharia.

Kadrewa village :—
Lakh Jharia, Kera Jh., Kunwari Jh., Batanu Nala.

Banjaridand village :—
Near Kotmi Pahar in Amnara.

Bhukbhuki village :—
Sonwahi Nala.

Chitajhor village :—
Kheradol Nala.

Ponri village :—
Ponri Nala.

It is not improbable that an examination of the N. W. portions of the field would reveal the existence of other workable areas.

Other analyses.

The following analyses are taken from Mr. Harris' report, with the exception of those marked G. S. I., which represent samples collected by the Superintendent of the State and analysed in the Geological Survey Laboratory :—

——	Calorific value, calculated.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
Kurasia Area.					
Gorghela Nala (4) . .		8·00	33·81	46·73	11·46
Nag Jhula (11) . . .		7·25	33·50	41·27	17·98
Saruplikha N. (13) . .		8·00	28·52	49·68	13·80
Kukri N. (27) . . .		4·60	38·06	48·00	9·34
Kukri N. (27) (G. S. I.) .	6,650	9·18	33·28	51·28	6·26
Kundo Pani (26) . .		6·85	28·92	46·07	18·16
Bijaura Jharia (7) . .		7·45	28·04	55·48	9·03
Lachhman Jharia (17) .		3·80	31·04	50·72	14·44
Chiriapani (22) . . .		5·00	36·67	49·02	9·31
Kheradol N. . . .		3·00	30·07	45·79	21·14
Do. (G. S. I.) . .		4·55	27·45	43·66	24·34
Chirmiri Area.					
Kaoria Nala (33) . .		4·60	38·06	48·00	9·34
„ (33) (G. S. I.)	6,850	7·22	34·10	52·76	5·92

Two analyses are also given in Hughes' memoir (*op. cit.*, p. 203) :—

—	Water, hygroscopic and combined.*	Volatile matter.	Fixed carbon.	Ash.
Kurasia, ½ mile S. E. (? Bijaura Jharia) .	2·20	29·15	64·65	6·20
„ 1½ miles S. S. E.	6·84	32·43	59·95	7·62

* Not included in the total.

CHAPTER IX.

KOREAGARH COALFIELD.

This, the third of the Korean coalfields, is the smallest, having an area of about 6 square miles.[1] Lala Hira Lal who surveyed it made only a hurried examination and found no seams of any value. In a stream-bed on the south slope of Koreagarh Hill he found a section showing 29″ coal in 4 seams in a total thickness of 7′8″; he also found a 6″ band of coal near Dugidei Hill. Mr. Harris reports the location of three exposures with thicknesses varying from 3 to 5 feet, with intervening bands of stone. They occur in the Ganga Gauri Jharia, Sendha Am Jharia, and Bela Jharia, respectively. The coal appears to be of medium quality. The manager of the Khargaon Zamindari, in a list of the known coal exposures in his zamindari, gives the following additional localities :—

Koreagarh :—

Mendabera Nala, Lanjhar Nala.

Duggi :—

Chatapani Nala, Malin Ghag, Kurlia Ghag, Bija Ghag, Damankund Ghag.

I was unable to visit this field myself.

[1] Hughes, *op. cit.*, p. 204.

CHAPTER X.

THE JHAGRAKHAND COAL AREA.

This is the south-eastern corner of the Sohagpur coalfield, projecting into Korea State over an area of about 22 square miles on the western side of the Hasdo river. It is a narrow strip 11 miles long from north to south, and 1 to 3 miles broad. It is crossed by the Jhagrakhand, Kulharia, and Neori streams, in all of which coal has been found (Hughes, *op. cit.*, p. 198), an analysis given by Hughes showing :—

Moisture	6·7
Volatile matter	28·2
Fixed carbon	59·6
Ash	5·5
	100·0

Mr. Harris reports the existence of three exposures in the Kulharia Nala, in two of which the coal is only 2 feet thick, and of no value, whilst in the third it is 5 feet thick.

CHAPTER XI.

GENERAL ECONOMIC SUMMARY.

From the foregoing pages it is evident that coal of good quality, and in sufficiently thick seams to deserve careful investigation, exists in both the Sanhat and Kurasia coalfields.

In the *Sanhat field* two seams of value were examined. The lower of these (No. 1) is valueless in the western half of its course, but shows thicknesses of 4′+ to 9′ over a length of 16 miles in its eastern portions. The analyses of the samples show the following limits and mean :—

—	Limits.	Mean.
Moisture	3·18 to 8·20	5·79
Volatile matter	26·98 to 29·50	28·22
Fixed carbon	37·60 to 50·46	44·80
Ash	15·38 to 32·24	21·19
		100·00

The upper seam (No. 2) is valueless in its eastern portions, but ranges from $3\frac{1}{2}'+$ to $9'\ 9''+$ towards the west. The samples taken show the following limits and mean :—

—	Limits.	Mean.
Moisture	3·10 to 5·71	4·19
Volatile matter	21·06 to 26·33	24·00
Fixed carbon	36·82 to 50·16	44·00
Ash	22·98 to 36·68	27·81
		100·00

Both seams dip, on the average, to the N. N. W., at an angle varying from 5° to 15° or more.

In the *Kurasia field* two areas were examined. In the *Kurasia area*, where 6 coal horizons were noted, horizon 4 is the most important, the coal ranging in thickness from 1′ to 8′ 6″ (2 to 5 seams). This horizon might, very likely, be proved by boring to cover about 4 square miles: an average thickness of 5 feet for the coal would correspond to $5\frac{1}{2}$ million tons per square mile. The samples show the following range and mean composition for the coal:—

——	Limits.	Mean.
Moisture	7·52 to 10·74	8·66
Volatile matter	30·12 to 31·32	30·92
Fixed carbon	46·96 to 49·88	48·86
Ash	9·32 to 13·82	11·56
		100·00

Horizons 3 ($11\frac{1}{2}$′ coal at one locality—Bijaura Jharia) and 2 (8′ coal at one locality—Gorghela Nala) are also worth investigation.

In the *Chirmiri area* of this field, the finest series of coal seams in the State is exposed in the Kaoria Nala at and below a waterfall known as the Karar Khoh. Seven seams of an aggregate thickness of 36 feet were measured, the analyses showing the following range and mean composition:—

——	Limits.	Mean.
Moisture	6·24 to 9·08	7·7
Volatile matter	23·48 to 33·86	29·1
Fixed carbon	48·08 to 54·20	51·2
Ash	5·50 to 16·72	12·0
		100·00

This series of seams (horizon 4) appears to thin out rapidly in all directions, but, even so, there is possibly 1 to $1\frac{1}{2}$ square miles, or even 2 square miles, over which the coal is at least 10 feet thick ; this thickness corresponds to 10·9 million tons coal per square mile. It is considered extremely probable that at least 7 million tons of good coal are available, with the possibility of 20 to 30 million tons. In this field dips are very low—practically horizontal as a rule. There is also a possibility of workable coal in horizon 5 in Bartunga Hill.

In both fields small faults (probably not very numerous) will probably be discovered, whilst the seams will at times be found to vary greatly in thickness in a short distance. The seams usually have a sandstone roof, which is massive, and, though rather friable, will probably be found to be fairly sound. But it is possible that the master-joints already referred to (p. 178) may cause a tendency to subsidences. Water is likely to be abundant in many places, and a considerable expenditure on pumping will doubtless be necessary.

As for labour, it should be good, for the inhabitants are largely aboriginals—Gonds, Rajwars, etc.—and accustomed to hard work in the shape of carrying heavy loads slung across their shoulders by means of *bhangis*. The population is small—only 62,107 in 1911, or 38 persons per square mile, according to the Gazetteer. But the State affords them at present very little occupation, cultivation being scanty, and it is likely that sufficient labour will be obtainable for any moderate enterprise.

At present Korea State is in a primitive condition, on account of its isolation from more civilised parts, and the old-fashioned scale of prices still prevails. Foodstuffs are very cheap, rice being (February 1913) 25 seers and milk 20 seers to the rupee, for instance, against prices of 10 seers of rice and 8 seers of milk to the rupee, even such a short way off as Pendra Road Railway Station. The consequence is that labour is exceedingly cheap, 1 anna a day being the nominal coolie wage.

But once coal-mining operations begin, higher rates will prevail. For without a railway the coal cannot be profitably worked, and a railway will speedily put Korea into market communication with the rest of India. Coolie wages will probably begin at 2 annas a day, and as the prices of foodstuffs adjust themselves to those of more accessible parts, wages will rise to 3 annas, and

later on probably to 4 annas, which seems now to be the standard wage in those parts of the Central Provinces where there is any considerable demand for labour, as in mines and railway construction. Once transport facilities exist there will probably be an extension of cultivation, and a small export of grain, together with a considerable export of lac (at present carried on pack bullocks), will bring revenue to the railway. But of much more importance than these, so I am informed by the Superintendent of the State, will be exports of timber, which will be on a large enough scale to support a railway, even without the coal.

The question of alignment of necessary railways I have not considered, this being outside my province. But Mr. Harris, in his report to the Central Provinces Administration, suggests a line from Jaithari station, Bengal-Nagpur Railway, in Rewah State, entering Korea to the west of Balbahara, and running eastwards as far as Patna, a total distance of 67 miles. According to this alignment the railway would keep just to the south of the southern edge of the Sanhat field; and in the event of coal being worked separate branch lines would be necessary to the Kurasia field, and to the Ghutra and Charcha areas of the Sanhat field.

The question of market for the coal produced also lies outside my province. But there would probably be a local outlet for a portion of it for railway purposes, if the quality be approved. As competitors it is necessary to consider the Umaria and Johilla fields in Rewah State to the west of Korea, and the group of coal-fields (Raigarh, Laphagarh, etc.,) lying on the north-eastern and eastern fringes of Chhattisgarh.

APPENDIX I.—CORRELATED LIST OF COAL OUTCROPS.

A. SANHAT FIELD.

Horizon I.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details	Dip.	Sample No.
1	Murma (Karimati East).	Pharkapani Nala (tributary of Gej N.)	1965 .	.... Sandstone . . 7′ 9″+*coal* . . . Note.—¼ to ½ of whole is shale coal.	16° to N. N. W.	K. 42.
2	Rakeya	Parewa Ghag (tributary of Gej N.)	1855 .	.... Sandstone . . 2′ 8″ *coal* . . . 1″ shale . . . 6″ *coal* . . . 10″ shale coal . . 1′ 2″ *coal* . . . . shaly micaceous sandstone.	7°-12° to N.	K. 43 (excludes 11″ shale and shale coal).
3	Charcha	Diwan Dham N. (tributary of Gej N.)	1925 .	.... Sandstone . . 2′+ *coal* . . .	10° to N. 15° W.	..
4	Nagar .	Biyah Mandha N. (tributary of Jhunka N.).	2010 .	.... Sandstone . . 9″ *coal* . . . . sandstone . .	10° to W. 20° N.	..
5	Do. .	Dummar Nakha N. (tributary of Halphali N.).	1973 .	.... Sandstone . . 9′ 0″ *coal* . . . 8″+ shale . . . 1′-1½′ coaly shale below water.	10° to N. 5° E.	K. 45 (about ½ shaly coal excluded).
6	Harra .	Tutina Jharia (tributary of Jura N.).	1800 to 1870.	Sections up to 6″ thick of same seam seen at intervals for about 1 mile up nala, owing to changing dip and strike.	17° to N. to 10° to S. S. W. to 5° to E. 10° N.	..
7	Do. .	Ghogra N. (tributary of Jura N.).	1827 .	.... Sandstone . . 1′ 2″ *coal* (8″ and 2½′ in two other places) 1′ 8″ micaceous and sandy shales.	15° to N. 20° E.	..
8	Kirwahi	Kirwahi Ghag, Hasdo R.	1800 .	.... Sandstones . 3′ black sandy shales . 6′ 0″ shaly micaceous sandstones. 3′ shaly sandstones . 11′ black shale . . 12′ sandstone with shaly partings. 2′ 6″ coaly shale partly *coal*. 2′ micaceous sandstones, carbonaceous and shaly above.	Rolling about N. E. axis.	

Horizon 1—*contd.*

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
9	Salba .	Dhuneti Ghag (on Dhuneti N. a tributary of Hasdo R.)	1745 .	.... Sandstone . . 3′ 6″ carbonaceous shale with $\frac{1}{16}$″ coal layers. .... ripple-marked argillaceous and micaceous sandstones.	6° to W. by N. to and to N. 20° W.	..
10	Balbahara	Soa Pani (tributary of Hasdo R.).	1720 .	.... Sandstones . . 7″ *coal* . . . 7″ carbonaceous sandstones. 4′ 0″ obscured . . 4′ 0″ flaggy micaceous sandstones.	..	..

Sanhat Field—Horizon 2.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
11	Rakeya	Saman Dei N. (tributary of Gej N.).	2165 .	.... Sandstones . . 8″ *coal* . . . 4′ 0″ sandy micaceous shale. 2′ 0″ obscured . . 6″ + *coal.* (in situ) . . .... obscured . .	4° to N. N. W.	..
12	Sardih .	Gae-mara N. (tributary of Jhunka N.).	2125 .	.... Sandstone . . 1′ 0″ *coal* . . 0′ 7″ *coal shale* . . .... obscured . .	12°-15° to N. by W.	..
13	Nagar .	Biyah Mandha N. (tributary of Jhunka N.).	2150 (2A.)	.... Sandstone . . 4′ 0″ *coal* . . . 0′ 5″ micaceous shale . 1′ 6″ micaceous sandstone 2″ carbonaceous sandy shale. 4′ + micaceous sandstone	Small to N. N. W.	K. 44 (whole seam).
14	Do. .	Biyah Mandha N.	2116 .	.... Sandstone . . 2′ 0″ *coal* . . . 2″ sandy shales . . 1′ 2″ shaly micaceous sandstone. 4′ 6″ micaceous sandstone 6″ carbonaceous shale . .... obscured . .	Small to N.	..
15	Kirwahi	Pakri Dabra N. (tributary of Hasdo R.).	1918	.... Sandstone . . 2′ 0″ *coal* . . . . carbonaceous shale under water.	..	.
16	Ghutra .	Dhuneti N. (tributary of Hasdo R.).	1935 .	7′ 0′ sandstone . . 3′ 6″ + *coal with coal-shale*	3° to S. S. W.	K. 46, excluding 1′ coal-shale.

Sanhat Field—Horizon 2—*contd.*

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
17	Salba .	Sitamarhi N. (tributary of Dhuneti N.).	1978 .	.... Sandstone . . 2′ 0″ *coal* . . . 4″ carbonaceous shale . 3″ *coal* . . . 1″ carbonaceous shale . 4″ shale . . . 6″ *coal* . . . 2″ shale . . . 8″ carbonaceous shale . 1′ 9″ *coal* . . . 2″ shale . . . 1″ *coal* . . . 2″ shale . . . 3″ *coal* . . . 1″ shale . . . 1″ *coal* . . . 4″ shale . . . 1″ *coal* . . . 4″ shale . . . 3″+ shaly *coal* . .	8° to S. W. 5′ 3″ coal in 7′ 11″ seam.	K. 47, excluding the 1″ bands.
18	Balbahara	Soa Pani (tributary of Hasdo R.).	1885 .	.... Sandstone . . 2′ 6″ *coal* . . . 12′ 2″ shales and sandstone, micaceous and carbonaceous. 1′ 5″ sandstone . . 4″ carbonaceous sandstone. 1′ 4″ carbonaceous shale . 7′ 3″+*coal seam* . . 3′ 0″ *coal* . . . 1′ 0″ carbonaceous shale . 3′ 3″+ *coal* . . . [water in a pool] .	Gentle to N. W.	Lower seam: K. 48 representing the bright coal, K. 49 the shaly coal. Ratio about 3 : 1.

Sanhat Field—Horizon 3.

19	Charcha	Bar Pani (tributary of Gej N.).	2307 .	.... Sandstone . . 1′ 9″ *coal* . . . 1′ 4″ micaceous sandstone 4″ *coal* . . . 4″ sandy micaceous shale. 8″ *coal* . . . 1′+ micaceous sandstone	4° to N. N. W.	..

Sanhat Field—Western end.

20	Bahi .	Papar Jhorka (tributary of Hasia R.).	..	1′ 0″ micaceous carbonaceous shale. 1′ 3″ micaceous sandstone 8″ micaceous carbonaceous shale. 3′ 5″ *coal* with 2″ shale . 5″ micaceous black shale .... micaceous sandstone	12° to N. 20° W.	K. 50, 2″ shale excluded.

Sanhat Field—Western end—*contd.*

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
21	Bahi .	Hasia R. (tributary of Hasdo R.).	..	6′ 0″ sandstone . . 5″ argillaceous sandstone 6″ carbonaceous shale . with thin *coal* band. 3½″ *coal* . . . 7½″ shale with thin coal band. 2″ *coal* . . . 2½″ *shale coal* . . 1′ 10″ *coal* . . . 1′ 6″ argillaceous sandstone. .... sandy shale with thin coal band.	11° to W. 20° N.	..
22	Putadand.	Khurpi Dhar (tributary of Karakuchar N.).	..	.... Sandstone . . 1″ shale . . . 1′ 0″ *coal* . . . 2′ 7″ black micaceous argillaceous sandstone. 1′ 4″ black shale . . 2½″ *coal* . . . 2′ 7″ *shale coal* . . 1′ 0″ shale with thin *coal* bands. 2′ 6″ black shale . . .... sandstone . .	.. }3′ 9½″ (2½″ coal to 1′ 0″ shale with thin coal bands)	K. 51 from the 1′ seam.
23	Do. .	Khurpi Dhar	..	.... Sandstone . . 4′ 7″+*coal* . . .	7° to E. 15° S.	K. 52.
24	Kerabahara.	Gilapani Nala (tributary of Gundru N.).	..	.... Sandstone . . 5″ *coal* . . . 1″ shale . . . 4′ 2″+*coal* with thin shale partings.	To N. 30° W.	K. 53 represents the whole 4′ 7″ coal.
25	Do. .	Karuabara Nala.	..	2′ 0″ *coal* . . . 2″ coal shale . . 1″ *coal* . . . 6″ coal shale . . 1″ *coal* . . . 7″ *shale coal* . . .... black shale . .	10° to W. 5° S. }3′5″+	..
26	Bhainsdari (near Bichatola).	Kewai Nala and a tributary.	..	+1′ sandstone . . 1′ 1″ coal shale (2′ 2″ in tributary). 3½″ sandstone . . 4″ black shale . . .... micaceous sandstone	6° to N. 20° E.	..
27	?Kelhari	Barni Nala (tributary of Kewai N.)	..	.... Sandstone . . 1″ shale . . . 9″ *coal* . . . 11″ black shale . . 5½″ *coal* . . . 2″ micaceous argillaceous sandstone. 1′ 5″+black shale . .	Slight to W. 30° S.	..

B.—KURASIA FIELD.

KURASIA SECTION.

Horizon I.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet	Details.	Dip.	Sample No.
1	Dubchola (?)	Gorghela Nala	1761 .	.... Sandstone . . 3″ coaly shale . . 4″ *coal* . . . 3″ coal shale . . 2½″ *coal* . . . 3″ sandy shale . . 6″ shaly sandstone . 2½″ *coal* . . . 2½″ shale . . . 1½″ *coal* . . . 2″ coal shale . . 6″ *coal* . . . 2′ 0″ shale . . . 4″ *coal* . . . 6″ shale . . . 1′ 0″ argillaceous sandstone. 1′ 0″ shale and sandstone 3″ *coal* . . . 8″ sandy shale . . 1′ 0″ shaly sandstone . 4′ 0″ argillaceous sandstone. 2″ shale *coal* . . 2′ 9″ argillaceous sandstone. 5″ *coal* . . . 1″ coaly shale . . 1′ 6″ argillaceous sandstone. 9″ shale . . . 2′ + argillaceous sandstone.	..	K. 41 represents top 6 seams (23″ coal).
2	Do. .	Tributary of Gorghela Nala.	1750 .	1′ to 2′ zone with lenticular coal strings or seams up to 2″ thick—?crushed.	Slight to N.	..
3	Dubchola (?)	Gatti Jharia (tributary of Gorghela).	1790 .	.... Sandstone . . 11″ sandy and coal shale 6″ *coal* . . . 1½″ shale . . . 3″ *coal* . . . 5″ shale . . . 7″ *coal* and *coal shale* . 2′ 4″ sandstone . . 8″ + shale and shaly *coal*. 4′ 0″ obscured . . .... sandstone . .	Slight to N.	.

Kurasia Section—Horizon 2.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
4	Kurasia	Gorghela N.	2011 .	9′ 0″ sandstone . . . 1′ 0″ flaggy shaly sandstone. 8′ 0″ *coal* . . . 7″ shaly and carbonaceous sandstone. 7″ white sandstone . 2′ 3″ shaly sandstone . 7″ shaly sandstone and shale. 2″ *coal* . . . 2′ 0″ micaceous sandstone	..	K. 25—top 4½′ good coal K. 26.—Bottom 3½′ largely shaly coal with basal 8″ good coal.

Kurasia Section—Horizon 3.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
5	Kurasia	Gorghela N.	2052 .	.... Sandstones . . 6″ obscured . . 2′+ *coal* . . . 3′ 0″ approx., sandstone. 4″ *coal* . . . 6″ shale . . .	..	..
6	Do. .	Daukihuri (in Nag Jhula).	2060 .	.... Sandstone . . 3′10″ *coal* . . . 1′+ black shale . .	..	Top 6″ not sampled, next 2′ very weathered, K. 27. Basal 1′ 4″, K. 28.
7	Do. .	Bijaura Jh. (tributary of Kudra N.)	2045 .	5′ 0″ sandstone . . 9′ 0″ *coal* (and coal shale) 4′ 0″ obscured . . 2′ 6″ *coal* . . . . sandstone .	Slight to N. by W.	Top 4′ 3″, K. 33. 1″ carbonaceous shale, omitted. Bottom 4′ 8″ of coal shale and bright coal. K. 34 of coal shale only. K. 35 is whole of lower 2′ 6″ seam.
8	Do. .	Bijaura Jh. tributary.	2021 .	12′ 0″ sandstone . . 3′ micaceous sandy shale 4′ 3″ *coal* . . . 3″ shale . . . . sandstone . .	..	..
9	Do. .	Lachman Jh. (tributary of Kudra N.)	2061 .	15′ 0″ sandstone . . 4′ 0″ grey shale . . 1″ carbonaceous shale . 3′ 2″ *coal* . . . 10″+ shaly micaceous sandstone.	..	..
10	Do. .	Chirra Jh. (tributary of Dharhund N.)	2049 .	.... Sandstone . . 4″ *coal* . . . 1′ 4″ shaly sandstone .... sandstone . .	5°-10° to W. S. W.	..

Kurasia Section—Horizon 4.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
11	Kurasia	Nag Jhula (tributary of Gorghela).	2129 .	.... obscured by sandstone, sandstone blocks. 4″ grey shales . . 2′ 0″ *coal* . . . 1′ 0″ shale and sandstone. 2′ 0″ *coal* . . . 9″ shale . . . 10″ *coal* . . . 3′ 6″ black shale . . 8″ *coal* . . . 8″ coaly shale . . 1′ 2″ *coal* . . . 3″+sandstone . .	..	K. 31 from all the seams.
12	Do. .	Ghumasarai N. (tributary of Gorghela).	2123 .	.... Sandstone . . .... obscured . . 4″ *coal* . . . 2′ 0″ sandstone . . 6″ shale . . . 2′ 0″ *coal* . . . 9″+shales . . . . obscured. . .	..	K. 32 of 2′ band.
13	Do. .	Saruplikha Nala (tributary of Gorghela).	2126 .	.... Sandstones . . 1′ 3″ shaly sandstone . 1′ 0″ shale . . . 4′ 0″ *coal* . . . 2′ 0″ obscured . . 2′ 0″ shaly sandstone . 2′ 6″ *coal* . . . . obscured . . 7′ 0″ sandstone . . 2′+coal, inferior . .	8° to S. 15° W. Section disturbed with a S. 35° E. fracture.	K. 29 of 2′ of top seam. K. 30 of whole seam.
14	Do. .	Ama Jh. (tributary of Gorghela).	2122 .	3′ 0″ sandstone . . . 3′ 0″ carbonaceous shale . 2′ 0″ *coal* . . . 8″ shaly sandstone . 5′ 0″ obscured . . 10′ 0″ shaly sandstone . 10″ *coal* . . . 8″+carbonaceous sandstone.	..	..
15	Do. .	Bansa Dandi (tributary of Gorghela).	2083 .	+10″ *coal* . . . 2″ argillaceous sandstone 1′ 0″ shales . . . 1′+ *coal* . . .	..	..
16	Do. .	Bijaura Jh. (tributary of Kudra N.).	2117 .	.... Sandstone . . 4″+*coal* . . . . débris . . .	..	..
17	Do. .	Lachman Jh. (tributary of Kudra N).	2137 .	(2142 ft.) coal (? upper seam). 5′ 0″ sandstone . . 4′+*coal* . . . 4′ 0″ obscured . . .... sandstone.	..	K. 36 of whole seam.
18	Do. .	Lachman Jh., tributary.	2126 .	30′ 0″ sandstone . . 1′+*coal* . . . 7′ obscure (with 1′ shale) +1½′ *coal* . . . . alluvium . .	..	..
19	Do.	Do. .	2124 .	.... sandstone . . .... shaly carbonaceous sandstone. 8″ black shale . . 2′ 10″+*coal* . . .	..	..

Kurasia Section—Horizon 4—*contd.*

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
20	Kurasia .	Lachman Jh., tributary.	2102 .	+3½′ coal . . .	..	..
21	Do. .	Chirra Jh. (tributary of Dharhund N.)	2155 .	.... Sandstone . . .... débris . . . 6″+*coal* . . . 9′ 0″ débris . . . +2′+*coal* . . .	15° to W. by N. in sandstone a little down stream.	..
22	Do. .	Do. .	2125 (? 21 repeated by faulting).	.... Sandstone . . 4′ 6″ *coal* . . . 13′ 0″ sandstone . . 3′8″ *coal* . . . 6″ shale . . . . sandstone . .	5° to S. W.	K. 38 of upper seam.
23	Do. .	Kurasia N. (tributary of Halphali N.).	2092 .	5′ 0″ sandstone . . 2′ 6″ *coal* . . . 1′ 6″+shale . . . . obscure, few feet . .... sandstone . .	Slight dip to N.	..
24	Do.	Do. .	2036 (23 repeated by fault).	3′ 0″ sandstone . . 3′ 0″ *coal* . . . 4″ shale . . . 1′ 0″+*coal* . . . . sandstone . .	Slight to S. W.	..
25	Do. .	Dudhania N. (tributary of Kurasia N.)	2062 .	.... sandy shale . . 1′ 0″ *coal* . . . 2′ 0″ shaly sandstone .	7° to W. S. W.	..

Kurasia Section—Horizon 5.

26	Kurasia .	Kundo Pani (source of Gorghela N.).	2209 .	.... Sandstone blocks . . +1′ *coal* . . . 6″ shaly sandstone . 4″ shale . . . 6″ argillaceous sandstone. 2′ 9″ *coal* . . . 2″ shaly sandstone . 1″ micaceous sandstone .... sandstone . .	..	..
27	Do. .	Kukri N. (tributary of Gorghela).	2222 .	.... Sandstone blocks . +1′ 2″ *coal* . . . 1′ 5″ sandstone and shale 2′ 3″ *coal* . . . 2″ sandy shale . . 10′+sandstone . .	..	..
28	Do. .	Ama Jh. (tributary of Gorghela).	2197 .	80′ sandstone cliff . 7′ 6″ sandy carbonaceous shales . . . 6″ ferruginous sandstone. 1′ 0″ carbonaceous shale. 3′ 6″ *coal* . . . 6″ carbonaceous shale . 2′ 3″+micaceous sandstone.	Slight to S. E.	K. 39—shale coal (say ¼ of seam) rejected.

Horizon 6.

28a	Kurasia.	Kundo Pani.	2312 .	Loose coal seen . .		

Chirmiri Section—Horizon 3.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
29	..	Kachhan Kundi.	1816 .	+ 20′ 0″ Sandstone . . 2′ 0″ shaly sandstone . 15′ 0″ sandstone . . 10″ *coal* . . . 5′ 0″ sandstone . . 1″ *coal* . . . 6″ black shale . . 7″ sandstone . . 9″ grey sandstone . 2′ 0″ shaly sandstone . 6″ sandy shale . . 3′ 0″ shaly sandstone .	General dip slight to E. S. E. Squeezed beds.	

Chirmiri Section—Horizon 4.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
30	Chirmiri	Upper Dubpani (Kaoria Nala).	2110 .	.... Sandstone blocks . 1′ 0″ black micaceous shale 4′ 6″ *coal* . . 8″ + shale . . .	Slight to W.	K. 40, excluding 9″ coal-shale and 1′ at the top, very weathered.
31	Do.	Chirmiri Nala (trib of Kaoria Nala).	2070 .	+15′ Sandstone . . 11″ *coal* . . . 4″ sandy shale . .	..	
				Right Bank. *Left Bank.*		
32	Do.	Dubpani (Kaoria Nala).	2030 .	Right Bank: Sandstones. 8″ sandy shale. 4″ sandstone. 3′ 5″ coal. 4″ carbonaceous sandstone. 1′ 0″ black shale. .... carbonaceous sandstone. Left Bank: sandstones . 8″ sandy shale. 4″ sandstone. 11″ coal . 2″ carbonaceous sandstone. 1″ coal. 4″ black shale.	5° to W. 35° S.	K. 1.
33	Do.	Karar Khoh and Hathbandha Nala (Kaoria Nala).	1940 .	Given in full detail in text (p. 205) 36′ *coal* (7 seams) in 48 feet of strata.	Rolling from S. S. E. to N. N. W.	K. 2 to K. 14.
34	Do.	Sare Nala (trib. of Kaoria N.).	1910 .	29′ 0″ shales and shaly sandstones. 1′ 0″ *coal* and carb. shale 4′ 0″ sandstone and shaly do. 2′ 6″ + *coal* . . . 4′ 6″ obscure. . . 8′ 0″ *coal* . . . 3′ 0″ shale . . . 19′ 0″ obscure (shaly sandstone at base). 4′ 0″ *coal* . . . 4′ 0″ obscure. . .	..	..

Chirmiri Section—Horizon 4—*contd.*

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
				2′ 0″ *coal* . . . 5′ 0″ shaly sandstone . 16′ 0″ obscure. . . 3′ 0″ shaly sandstone . 1′ 0″ shale . . . 3′ 0″ obscure. . . . . . . sandstone . .		
35	Chirmiri	Gaemara Nala (trib. of Kaoria N.).	1877 .	. . . . Sandstone . . 4′ 5″ *coal.* ? seam 1. . 2′ 0″ coal shale . . 3′ to 4′ *coal.* ? seam 2 . 1′ 0″ coal shale . . 12′ 0″ coal at intervals . 20′ 0″ obscure. . . . . . . sandy shales .	12 to N. 30° W. ? Seams 3, 4, 5.	..
36	Do.	Trib. of Gaemara N.	1964 .	12′ 0″ shale and sandstone 4′ 0″ *coal.* ? seam 1. . 1′ 0″ black shale . . 2′ 6″ shaly sandstone . 4′ 0″ *coal.* ? seam 2 . 4′ 0″ carb. shale . 3′ 6″ *coal.* ? seam 3 . 8′ 0″ sandy shale . . 2′ 0″ *coal.* ? top of 4. .	..	K. 24 of top seam.
37	Do.	Trib. of Kaoria Nala below Hathbandha Nala.	1907 .	41′ 0″ shale and bedded sandstone and obscured. 6″ shale . . . 4′ 0″ coal seam 3 . . 6″ black shale . . 7″ *coal* seam 3A. . 2′ 6″ sandstone and shale 33′ 0″ obscure. . . . . . . sandstone . .	..	..
38	Do.	Barsi Pani (trib. of Kaoria N).	1887 .	50′ 0″ sandstone . . 15′ 0″ sandstone and shale 4′ 3″ *coal.* ? seam 1. . 10″ black shale . . 3′ 6″ shaly sandstone . 3′ 5″ *coal.* ? seam 2 . 3′ 6″ shale . . . 4′ 10″ *coal.* ? seam 3 . 4′ 6″ shale and sandstone 6′ + *coal.* ? seam 4 . obscure exposure of coal at 1849 feet.	Slight to N. N. W. & to W.	..
39	Do.	Manju Nacha N. (trib. of Kaoria N.).	2045 .	+2′+ *coal* in soil . .	? Karar Khoh series faulted up.	
40	Do.	Diwan Jh. (trib. of Karauli Dhar).	2005 .	. . . . Shaly sandstones . 1′ 0″ micaceous shale . 3′ to 4′ *coal* seam 1. . 1′ 0″ shale . . . 8″ + *coal* seam 2 . . 2′ to 3′ obscured . . 1′ 9″ sandy carb. shale . 1′ + *wet coal.* ? 3rd seam (might be seam 2 due to some dip in rock).	..	K. 20 from seam 1.

Chirmiri Section—Horizon 4—*contd.*

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
41	Kadrewa	Karauli Dhar (trib. of Kesmara N.).	1994 .	8′ 0″ sandstone . . 8″ black shale . . 20′ 0″ shaly sandstones and sandy shales. 9′ 0″ obscure . . . 2′ 0″ sandstone and shale 3′ + *coal* . . .	..	K. 19 of top 1½′. Remainder of seam too wet.
42	Chirmiri	Kachhan Kundi (trib. of Kaoria N.).	1941 .	.... Sandstone . . 2′ + *coal* . . .	Slight to E. N. E.	..
43	Do.	Kachhan Kundi (in a cleft).	1902 .	.... Sandstone . . 6″ shale . . . 13″ *coal* . . . 3″ sandy shale . . 6″ sandstone . .	42 repeated owing to dip (slight to E. N. E.) or to a fault.	..
44	Do.	Paraspani N. (trib. of Kachhan K.).	1936 .	Few inches carb. sandy shale. 14″ *coal* . . . 6″ carb. sandstone .	..	..
45	Kadrewa	Kuar Jharia	1864 .	4′ 0″ sandstone . . 6″ shaly sandstone . 1′ 0″ carb. shale . . 5″ *coal* . . . 7″ shale . . . 6″ *coal* . . . 1′ 0″ shale . . .	..	..
46	Do.	Jam Nala .	1889 .	70′ 0″ sandstone . . 1′ 0″ clay at junction . 2′ 6″ carb. shale . . 10″ *coal* . . . 8″ + black shale . . 7′ 0″ obscure . . 10″ shale . . . 1′ + *coal* . . .	..	K. 18 of upper seam.
47	Do.	Bija Nala .	1879 .	.... Sandstone . . 1′ 6″ shale . . . 3″ *coal* . . . 1′ 0″ argill. sandstone . 3′ 0″ shale . . . 8″ *coal* . . . 17″ coaly shale . . .... Sandstone . .	..	K. 17 of lower seam.
48	Do.	Bhalubhil Jh.	..	.... Sandstone . . 1′ 0″ sandy shale . . 1′ 6″ *coal* . . . 8′ 6″ obscure and sandstone 4′ 0″ *coal seam* { 1″ coaly shale. 1′3″ good coal. 1′9″ coaly shale. } .... micaceous sandstone	..	K. 16 represents middle 1′ 3″ of lower seam.
49	Do.	Am Nala .	..	50′ 0″ sandstone . . 6′ . . . 2′ + coaly shale . . 2′ 0″ sandstone and shale 3′ 0″ *coaly* shale and poor *coal*. 7′ 0″ obscure . . . .. Sandstone . .	..	K. 15, picked coal from lower seam (about ⅓).

Chirmiri Section—Horizon 5.

No. of exposure.	Village.	Stream or River.	Altitude of top of coal in feet.	Details.	Dip.	Sample No.
50	Kadrewa	Trib. of Karauli Dhar.	2103 .	Obscure 1′ *coal* resting on 6″ + shaly sandstone.	..	..
51	Do.	Bara Am N. (trib. of Karauli Dhar).	2093 .	.... Sandstone 1′ 0″ shaly sandstone . 10″ + *coal* . . .	..	..
52	Do.	Bare Mandil N. (trib. of Karauli Dhar).	2104 .	60′ 0″ Sandstone . . 3′ 6″ *coal* . . . 1′ 4″ shaly sandstone . 3″ *coal* . . . 1′ 0″ shale . . . 23′ 0″ sandstones and shales. 4′ 0″ + *coal* . . .	..	K. 23 of top seam.
53	Do.	Sendri Ama N. (trib. of Karauli Dhar).	2109 .	20′ Sandstone . . 3′ 8″ *coal*—largely shaly 20′ 0″ sandstones and shales. 4′ 2″ + *coal* . . . 7′ 0″ obscure. . . .... sandstone . .	..	..
54	Do.	Bijaura N. (trib. of Karauli Dhar).	2118 .	.... Sandstone . . 4′ 0″ *coal* . . . 15′ shales and sandstone .... boulders .	..	..
55	Chirmiri	Mangarmuhar N. (trib. of Kachhan Kundi).	2139 .	.... Sandstone cliff . 4′ 0″ *coal*—largely shaly 2′ 0″ sandstones and shales. 2″ *coal* . . . 1′ 5″ shaly sandstones . 2′ 0″ coarse sandstone . 5′ + *coal* . . . 12′ obscured . . .... sandstone . .	..	K. 21 of top seam. K. 22 of 1′ 6″—3′ 0″ of bottom seam, top 1′ 6″ and basal 2′ being too weathered and wet.
56	Do.	Samardhukela N. (trib. of Kachhan K.).	2161 .	.... Sandstone cliff . 2′ 2″ + *coal* . . . 13′ 0″ obscured . . 5′ 0″ shale and sandstone 2′ 0″ carb. shale . . 5″ sandstone . . 1′ 0″ carb. shale . . 4′ 0″ sandstone and obscure. .... carb. shale, properly top of lower *coal* seam.	..	..
57	Do.	(Trib. of Kachhan K).	2157 .	+ 3′ + *coal*, probably upper seam.		
58	Do.	Am Jharia (trib. of Kachhan K.).	2162 .	.... soil . . . + 2′ *coal*, sandstone and shale. 1′ 0″ shale . . . 2′ 0″ *coaly shale* . . 2′ 0″ obscured . . .... sandstone . .	..	..

APPENDIX II.—LIST OF KOREAN COAL OUTCROPS (AFTER HUGHES).

Village.	River.	Lat. N.	Long. E.
Amhar, 1 mile E. N. E. . . .	Ghungatta, a tributary of Hasdo .	23°29′	82°31′
Bahi, ¾ of a mile N. N. E. . .	A tributary of Hasia . . .	23°21′	82°15′
,, 1 mile S. S. W. . . .	,, ,, . . .	..	..
,, 1 mile S. E.	,, ,, . . .	..	..
,, 2 miles S. S. E. . . .	Hasia	..	..
,, 2¼ miles South . . .	,, ...	..	..
,, 2¾ miles South . . .	,, ...	..	..
,, 3¼ miles South . . .	,, ...	..	..
Balbahara, 1 mile N. N. E. . .	A tributary of Hasdo . . .	23°18′	82°19′
,, 1¼ miles N. . . .	A tributary of Karakachar . .	..	..
,, 1½ miles N. . . .	Eastern tributary of Karakachar .	..	..
,, 1 mile N. N. W. . .	,, ,, ,, .	..	..
,, 1 mile W. S. W. . .	,, ,, ,, .	..	..
,, 1¼ miles W. N. W. . .	Western tributary of Karakachar	..	..
,, 1½ miles W. N. W. . .	,, ,, ,, .	..	..
,, 2 miles W. N. W. . .	,, ,, ,, .	..	..
,, 2 miles W. N. W. . .	,, ,, ,, .	..	..
,, 2¼ miles N. W. .	,, ,, ,, .	..	..
,, 2½ miles N. W. . .	,, ,, ,, .	..	..
,, 2¾ miles W. N. W. . .	,, ,, ,, .	..	..
Balsing, ¼ of a mile N. N. W. . .	A tributary of Hasdo . . .	23°23′	82°21′
,, ¼ of a mile S. S. E. . .	,, ,, ...	..	..
,, 1½ miles N. N. E. . .	,, ,, ...	..	..
,, 1 mile N. E. . . .	,, ,, ...	..	..
,, 1 mile S. S. E. . . .	Hasdo	..	..
,, 1½ miles S. E. . . .	,, ...	..	..
Baser, ½ a mile W. N. W. . .	A tributary of Hasdo . . .	23°21½′	82°25′
,, 1 mile W. N. W. . . .	,, ,, ...	..	..
,, 1 mile S. W. . . .	Jura, a tributary of Hasdo . .	..	..
,, 1 mile S. S. W. . . .	,, ,, . .	..	..
,, 1½ miles S. S. W. . . .	,, ,, . .	..	..
,, ¾ of a mile S. E. . . .	Darpani	..	..
,, 1 mile S. E. . . .	,, ...	..	..

LIST OF KOREAN COAL OUTCROPS (AFTER HUGHES)—*contd.*

Village.	River.	Lat. N.	Long. E.
Bhoswai, ½ a mile S. W. . . .	A tributary of Hasdo . .	23°24′	82°37′
„ ½ a mile W.	„ „	..	..
Charcha, 1½ miles N. W. . .	A tributary of Gej . . .	23°20′	82°36′
„ 1 mile N. N. E. . .	„ „	..	..
„ ¾ of a mile N. E. . .	„ „	..	..
„ 1 mile E. N. E.. . .	„ „	..	..
Chatan, ½ a mile S.	Gandra Nadi	23°25′	82°11′
Chitajhor, ½ a mile S. S. W. . .	Kauria Nadi, branch . . .	23°23½′	82°23′
Deokhol, 1 mile N.	In a tributary of Gej . . .	23°22′	82°39′
Dubchola, 1½ miles N. . . .	Gorghela (Gurgheta) . . .	23°9′	82°27′
Ghutra, 1 mile W. S. W. . .	Hesin	23°21′	82°18′
„ 1 mile W.	„	..	..
„ 1½ miles W. S. W. . .	„	..	..
„ 1¾ miles W. S. W. . .	„	..	..
„ 2 miles S. W.	„	..	..
„ 2½ miles S. W. . . .	„	..	..
„ ½ a mile S. E.	„	..	..
Harra, ¼ of a mile N. W. . .	Eastern tributary of Jura . .	23°17½′	82°25′
„ ½ a mile N. N. W. . .	„ „ . .	..	..
„ ¾ of a mile N. N. W. . .	„ „ . .	..	..
„ 1 mile W. N. W. . . .	„ „ . .	..	..
„ 1½ miles N. W. . . .	„ „ . .	..	..
Kachar, ½ a mile N. N. E. . .	A tributary of Dhob Nadi . .	23°19′	82°26′
„ ½ a mile S. E. . . .	„ „ . .	..	..
„ ½ a mile E.	.... . .	..	..
„ 1 mile N. E. . . .	.... . .	..	..
„ 1½ miles E. N. E. . .	.... . .	..	..
Khairbana, 1½ miles S. S. E. . .	Kaoria	23°13½′	82°19′
Kirwahi, 1½ miles W. S. W. . .	Hasdo	23°20′	82°22′
„ a few score yards W. . .	At the falls in Hasdo . . .	..	..
„ 1½ miles N. . . .	Hasdo	..	..
Kurasia, ½ a mile S. E. . . .	Kudra branch, tributary of Hasdo	23°14′	82°27′
„ 1½ miles S. E. . . .	„ „ „	..	..
„ 2 miles S. W. . . .	„ „ „	..	..
„ 1½ miles S. . . .	Gorghela Nadi branch, tributary of Hasdo.	..	..
Kusaha, S. E..	Hasdo	23°26′	82°32′

LIST OF KOREAN COAL OUTCROPS (AFTER HUGHES)—*concld.*

Village.	River.	Lat. N.	Long. E.
Labji, 1 mile S. S. W.	A tributary of Jhunka Nadi	23°23′	82°32′
„ 1½ miles S. S. W.	„ „	..	..
Lai, ¾ of a mile N. E.	A tributary of Hasdo	23°17½′	82°21′
Latma, ¾ of a mile N.	Tributary of Hasdo	23°22½′	82°37′
Mouhari, ½ a mile S. E.	Keslara	23°26′	82°4′
Nerua, 1 mile N.	A tributary of Khatomadhar	23°25′	82°11′
Pathargaua, 1½ miles S. E.	A tributary of Goknai	23°26′	82°38′
Rataura, 1 mile N. E.	Gundrakund	23°23′	82°14′
„ ¼ of a mile W. N. W.	....	..	..
„ 1 mile W.	....	..	..
Roji, ½ a mile S. E.	? Khatomadhar	23°26′	82°7½′
Roudserai, 1 mile N. N. E.	A tributary of Goknai	23°26′	82°41′
„ 1 mile N. E.	„ „	..	..
Sanhat, 1 mile S. S. E.	Hasdo	23°29′	82°34′
„ 1½ miles S. S. E.	„	..	..
Tanjara, 1½ miles S. E.	A tributary of Goknai	23°29′	82°39′

APPENDIX III.—GEOGRAPHICAL INDEX.

Locality.	Latitude.		Longitude.		Pages.
	°	′	°	′	
Bela Jharia	..		..		211.
Bhainsadari	23	23	82	7	220.
Bhalubhil Nala	23	9	82	21	202, 203, 227.
Bhukbhuki	23	9½	82	24½	156, 209.
Bichatola	23	23	82	5½	151, 193, 220.
Bija Ghag (Duggi)	..		..		211.
Bija Nala (Kadrewa)	23	9	82	21	202, 203, 227.
Bijaura Jharia (Kurasia)	23	12¾	82	26½	180, 184, 195, 197, 198, 199, 200, 210, 214, 222, 223.
Bijaura Nala (Kadrewa)	23	9½	82	22½	202, 209, 228.
Biyah Mandha Nala	..		..		179, 180, 188, 190, 217, 218.
Bouridand	23	13½	82	14½	157.
Budra Nala	23	1	82	14	167, 170.
Buskata H. S.	23	21	82	35½	157
Chamat Hill	23	20½	82	45½	171.
Charcha	23	20	82	37½	174, 188, 190, 194, 216, 217, 219.
Chatapani Nala	..		..		211.
Char (Chare)	23	15	82	36½	162.
Chirmiri	23	10½	82	25	150, 151, 158, 160, 173, 175, 183, 188, 195, 196, 200, 201, 203, 209, 225, 226, 227, 228.

Locality.	Latitude.	Longitude.	Pages.
	° ′	° ′	
Gae-mara Nala	23 11	82 23¾	173, 190, 201, 203, 207, 218, 226.
Ganga Gauri Jharia	..	..	211.
Gatti Jharia	23 11	82 25¾	197, 221.
Gej Nala	23 17	82 37½	169, 170, 217, 218, 219.
Ghogra Nala	..	..	190, 217.
Ghumasarai Nala	23 12	82 25¾	197, 199, 223.
Ghutra	23 21	82 19½	149, 151, 155, 171, 180, 190, 191, 192, 193, 216, 218.
Gilapani Nala	23 23½	82 12	193, 220.
Gopath River	..	..	154.
Gorghela Nala	23 1¾	82 25½	168, 180, 181, 182, 188, 195, 196, 197, 198, 199, 200, 209, 214, 221, 222, 223, 224.
Gundru Nala	..	..	220.
Halphali Nala	23 15½	82 21	217, 224.
Harra	23 18½	82 25½	190, 194, 217.
Hasdo River	22 57½	82 26½	154, 157, 163, 169, 171, 179, 212, 217, 218, 219, 220.
Hasia Nala	23 18½	82 15½	193, 219, 220.
Hathbandha Nala	23 10½	82 23¾	201, 204, 205, 206, 225, 226.
Jaithari station	23 2¾	82 51½	149, 216.

Locality.	Latitude.		Longitude.		Pages.
	°	′	°	′	
Kera Jharia	..		..		209.
Kerabahara	23	24	82	28	151, 193, 220.
Kesmara	23	23	82	34	227.
Kewai Nala	23	$12\frac{1}{2}$	82	$5\frac{1}{2}$	220.
Khargaon	23	6	82	26	151, 152, 155, 161, 162, 164.
Kheradol Nala	..		..		207, 209.
Khurpidhar	23	$19\frac{1}{2}$	82	$17\frac{1}{2}$	193, 194, 220.
Kirwahi	23	20	82	$23\frac{1}{2}$	154, 190, 217, 218.
Kirwahi Ghag	..		..		179, 190, 217.
Kohi Madda Nala	..		..		194.
Kora	23	$4\frac{1}{2}$	82	$15\frac{1}{2}$	151.
Koreagarh	23	8	82	32	147, 149, 154, 155, 171, 211.
Kotmi Pahar	23	10	82	$28\frac{1}{2}$	209.
Kuar Jharia	23	$9\frac{1}{2}$	82	20	188, 195, 202, 227.
Kudra Nala	23	$10\frac{1}{2}$	82	31	195, 222, 223.
Kukri Nala	23	$12\frac{1}{2}$	82	26	198, 209, 224.
Kulharia Nala	23	$8\frac{1}{2}$	82	$14\frac{1}{2}$	171, 212, 147.
Kundo Pani	23	$12\frac{3}{4}$	82	$25\frac{3}{4}$	196, 197, 198, 209, 224.
Kunwari Jharia	..		..		209.
Kurasia	23	$13\frac{1}{2}$	82	26	148, 150, 151, 155, 156, 158, 171, 173, 183, 184, 185, 186, 188, 195, 196, 200, 201, 210, 213, 214, 221, 222, 223, 224, 228.

Locality.	Latitude.		Longitude.		Pages.
	°	′	°	′	
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Karasia Nala	23	14	82	25½	157, 173, 197, 198, 224.
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Mangar Muhar Nala	23	9¾	82	22¼	202, 203, 228.
Manju Nacha Nala	23	11	82	23	201, 207, 226.
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Mendabera Nala	..		..		211.
Mensarai Jharia	..		..		209.
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Neori Nala	23	2	82	17	171, 212.

Locality.	Latitude.		Longitude.		Pages.
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Sanhat	23	29	82	35	149, 150, 151, 155, 157, 173, 183, 184, 188, 213.

SUBJECT INDEX.

Photograph by L. L. Fermor. *G. S. I. Calcutta.*

Bartunga hill (2,917 feet) composed of Barakar sandstone resting on Talchirs (forming the foreground).

Fig. 1. Cliff of Talchir shales with thin limestone bands: Kudra Nala.

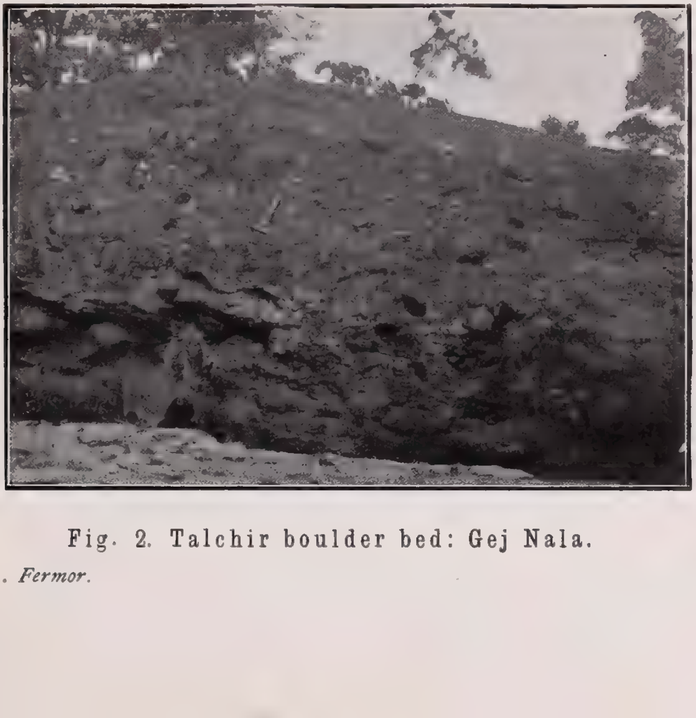
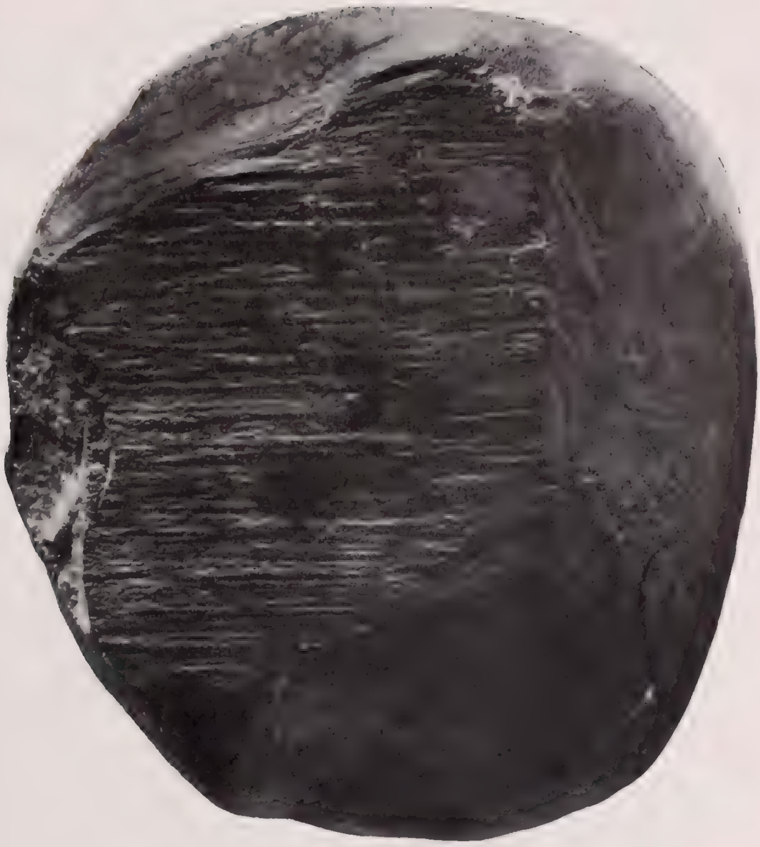


Fig. 2. Talchir boulder bed: Gej Nala.

Photographs by L. L. Fermor. *G. S. I. Calcutta.*



Scratched and facetted pebble of sandstone from Talchir boulder bed: Hasdo river, near Karimati. ($\frac{2}{3}$ *natural size*).

From a Photograph by K. F. Watkinson. *G. S. I. Calcutta.*

Fig. 1. Coal faulted against sandstone: Kurasia Nala.

Fig. 2. Barakar sandstone containing a coal seam squeezed into lenticles: Kachhan Kundi Nala.

Photographs by L. L. Fermor. *G. S. I. Calcutta.*

Fig. 1. Joint cleft in Barakar sandstone, occupied by the Kachhan Kundi Nala.

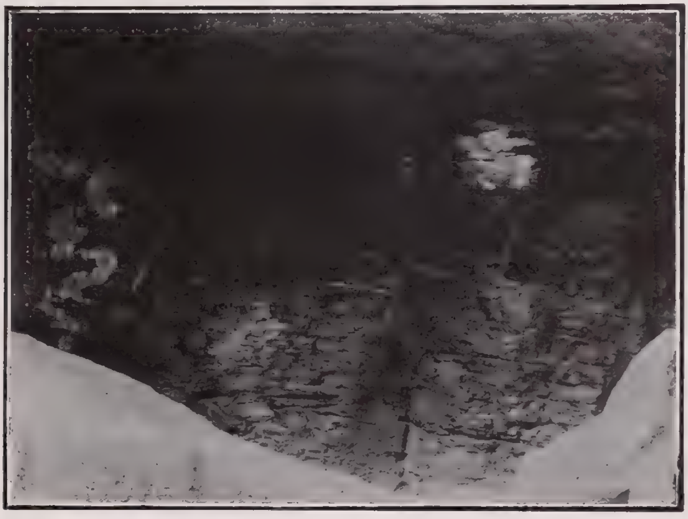


Fig. 2. Contorted sandstone veinlet in a coal seam: Charcha.

The sandstone roof is visible. The rock in foreground is fallen sandstone.

Photographs by L. L. Fermor. *G. S. I. Calcutta.*

Fig. 1. "Sun cracked" sandstone: Chirmiri.

Fig. 2. Potholes in Barakar sandstone: Kachhan Kundi Nala.

Photographs by L. L. Fermor. *G. S. I. Calcutta.*

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Cliffs of Barakar sandstone, south edge of Kurasia coal-field near Bartunga Hill. Foreground is Talchirs.

Fig. 1. Sandstone overhanging band of carbonaceous shale: Dhuneti Nala.

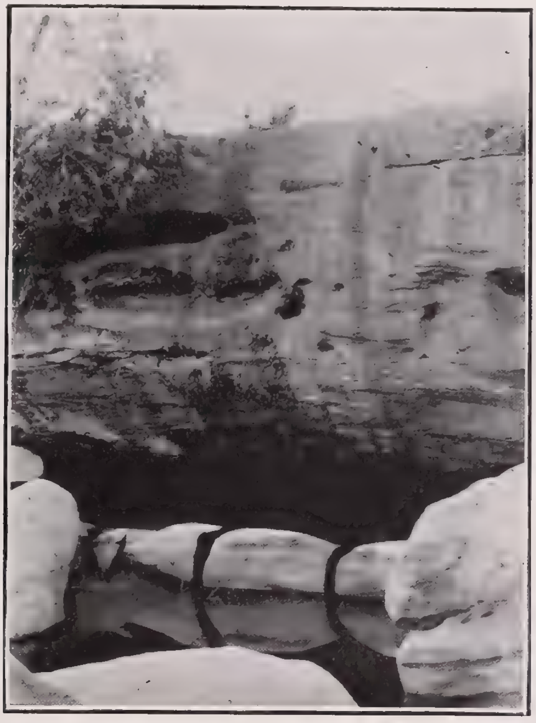


Fig. 2. Sandstone overhanging coal seams: Parewa Ghag.

Photographs by L. L. Fermor. *G. S. I. Calcutta.*

Photograph by L. L. Fermor. *G. S. I. Calcutta*

Kirwahi Ghag. A 3ft. seam of coaly shale at the base of fall.

Photograph by L. L. Fermor.

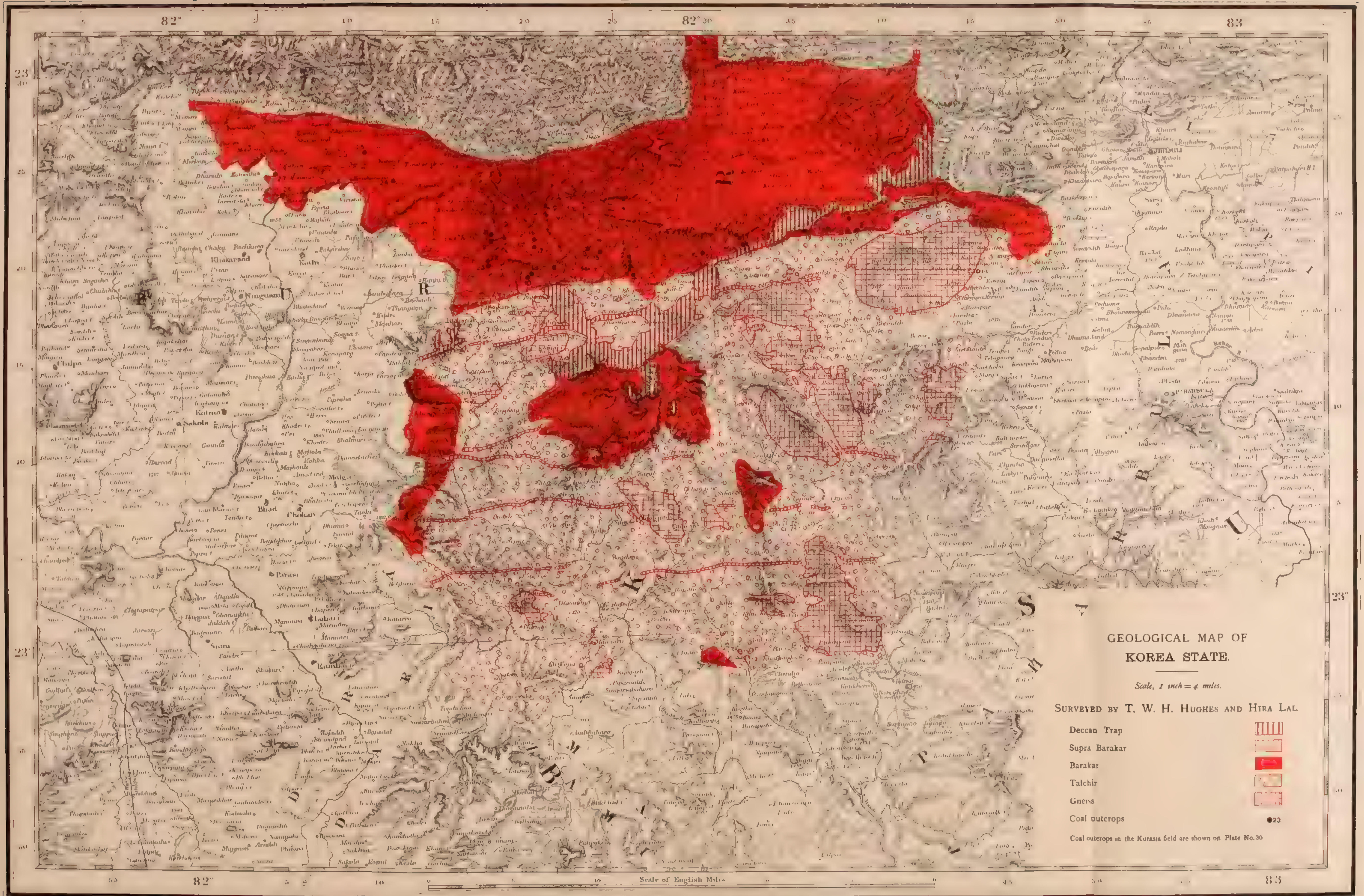
G. S. I. Calcutta.

Barrier of coal across Kaoria Nala.

The elephant is standing on the parting between seams 4 and 5.

MAP OF THE KURASIA COAL-FIELD.

Showing the positions of the coal outcrops enumerated in Appendix I.



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Part 3 (out of print).—Tertiary zone and underlying rocks in North-West Punjab. Fossil floras in India. Erratics in Potwar. Coal explorations in Darjiling district. Limestones in neighbourhood of Barakar. Forms of blowing-machine used by smiths of Upper Assam. Analyses of Raniganj coals.

Part 4 (out of print).—Geology of Mahanadi basin and its vicinity. Diamonds, golds, and lead ores of Sambalpur district. 'Eryon Comp. Barrovensis,' McCoy, from Sripermatur group near Madras. Fossil floras in India. The Blaini group and 'Central Gneiss' in Simla Himalayas. Tertiaries of North-West Punjab. Genera Chœromeryx and Rhagatherium.

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Part 1 (out of print).—Annual report for 1881. Geology of North-West Kashmir and Khagan. Gondwana labyrinthodonts. Siwalik and Jamna mammals. Geology of Dalhousie, North-West Himalaya. Palm leaves from (tertiary) Murree and Kasauli beds in India. Iridosmine from Noa-Dihing river, Upper Assam, and Platinum from Chutia Nagpur. On (1) copper mine near Yongri hill, Darjiling district; (2) arsenical pyrites in same neighbourhood; (3) koalin at Darjiling. Analyses of coal and fire-clay from Makum coal-field, Upper Assam. Experiments on coal of Pind Dadun Khan, Salt-range, with reference to production of gas, made April 29th, 1881. Proceedings of International Congress of Bologna.

Part 2 (out of print).—Geology of Travancore State. Warkilli beds and reported associated deposits at Quilon, in Travancore. Siwalik and Narbada fossils. Coal-bearing

rocks of Upper Rer and Mand rivers in Western Chutia Nagpur. Pench river coal-field in Chhindwara district, Central Provinces. Borings for coal at Engsein, British Burma. Sapphires in North-Western Himalaya. Eruption of mud volcanoes in Cheduba.

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Part 2.—Earthquake of 31st December 1881. Microscopic structure of some Himalayan granites and gneissose granites. Choi coal exploration. Re-discovery of fossils in Siwalik beds. Mineral resources of the Andaman Islands in neighbourhood of Port Blair. Intertrappean beds in Deccan and Laramie group in Western North America.

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Part 3.—Retirement of Mr. Medlicott. J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of Lower Himalaya, Garhwal, and Kumaun, Section I. Geology of Simla and Jutogh. 'Lalitpur' meteorite.

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Part 1.—Annual report for 1890. Geology of Salt-range of Punjab, with re-considered theory of Origin and Age of Salt-Marl. Graphite in decomposed Gneiss (Laterite) in Ceylon. Glaciers of Kabru, Pandim, etc. Salts of Sambhar Lake in Rajputana, and 'Reh' from Aligarh in North-Western Provinces. Analysis of Dolomite from Salt-range, Punjab.

Part 2.—Oil near Moghal Kot, in Sheráni country, Suleiman Hills. Mineral Oil from Suleiman Hills. Geology of Lushai Hills. Coal-fields in Northern Shan States. Reported Namsèka Ruby-mine in Mainglôn State. Tourmaline (Schorl) Mines in Mainglôn State.—Salt-spring near Bawgyo, Thibaw State.

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Part 3.—Cambrian Formation of Eastern Salt-range. Giridih (Karharbari) Coal-fields. Chipped (?) Flints in Upper Miocene of Burma. Velates Schmideliana, Chemn., and Provelates grandis, Sow. sp., in Tertiary Formation of India and Burma.

Part 4.—Geology of Wuntho in Upper Burma. Echinoids from Upper Cretaceous System of Baluchistán. Highly Phosphatic Mica Peridotites intrusive in Lower Gondwana Rocks of Bengal. Mica-Hypersthene-Hornblende-Peridotite in Bengal.

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Part 2.—Cretaceous Rocks of Southern India and geographical conditions during later cretaceous times. Experimental Boring for Petroleum at Sukkur from October 1893 to March 1895. Tertiary system in Burma.

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Part 2.—Cretaceous Deposits of Pondicherri. Notes.

Part 3.—Flow structure in igneous dyke. Olivine-norite dykes at Coonoor. Excavations for corundum near Palakod, Salem District. Occurrence of coal at Palana in Bikanir. Geological specimens collected by Afghan-Baluch Boundary Commission of 1896.

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Part 3 (out of print).—Petrology and Manganese-ore Deposits of Sausar Tahsil, Chhindwara district, Central Provinces. Geology of part of valley of Kanhan River in Nagpur and Chhindwara districts, Central Provinces. Manganite from Sandur Hills. Miscellaneous Notes.

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Part 3 (*out of print*).—Explosion Craters in Lower Chindwin district, Burma. Lavas of Pavagad Hill. Gibbsite with Manganese-ore from Talevadi, Belgaum district, and Gibbsite from Bhekowli, Satar District. Classification of Tertiary System in Sind with reference to Zonal distribution of Eocene Echinoidea.

Part 4 (*out of print*).—Jaipur and Nazira Coal-fields, Upper Assam. Makum Coal-fields between Tirap and Namdang Streams. Kabat Anticline, near Seiktein, Myingyan district, Upper Burma. Asymmetry of Yenangyat-Singu Anticline. Upper Burma. Northern part of Gwegyo Anticline, Myingyan District, Upper Burma, Breynia Multituberculata, from Nari of Baluchistan and Sind. Index to Volume XXXIV.

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Part 2.—Indian Aerolites. Brine-wells at Bawgyo, Northern Shan States. Gold-bearing Deposits of Loi Twang, Shan States. Physa Prinsepii in Maestrichtian strata of Baluchistan. Miscellaneous Notes.

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Part 4.—Preliminary survey of certain Glaciers in North-West Himalaya. B.—Notes on certain Glaciers in Lahaul. C.—Notes on certain Glaciers in Kumaon. Index to Volume XXXV.

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